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DISCOVERY

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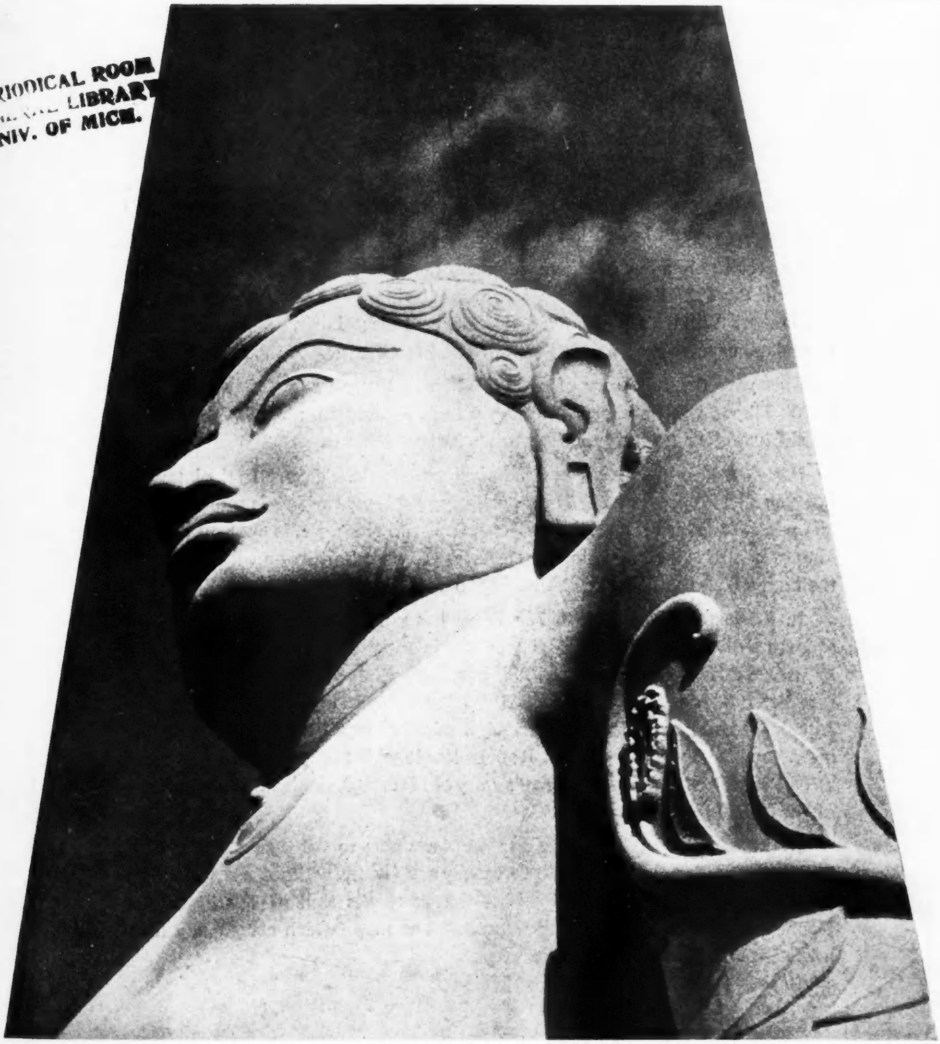

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A New Medical Discovery

THERE is no mode of dying which does not at times rouse man to anger and indignation against his inevitable fate. The death of children by infectious disease, of young adults by tuberculosis, of men and women in the prime of life by cancer, of older people by heart disease—each of these in turn makes man realize the forces of nature against which he has continuously to war. But that a mother should die in giving birth to her baby seems at once the most unnecessary, the most ironical and the most unfair of all nature's ways of attack. Only during the last few generations have any appreciable successes been scored on our side in the fight against death by disease. And, though with many halts and even set-backs, the fight against death in childbearing is gradually making motherhood the safe experience it should always be.

One hundred years ago in England, ten mothers died in childbirth for every thousand babies born at home, most of them of childbed fever. And if they sought the medical skill and attention of the hospitals of their day, their chances of dying were increased twofold. Nature was having it all her own way. But what was the reason for this relation between human interference and the increased number of maternal deaths? Many ideas had been put forward, but it was not until 1846 that Ignaz Semmelweiss, assistant professor in the maternity department in the Vienna hospital, really solved the problem. At that time between 10 and 20% of the women delivered at the hospital were dying—ten times as many as those who were delivered in their own homes. In 1846 Kolletschka, a colleague of Semmelweiss, died as a result of a wound sustained when performing a post-mortem examination on a woman. She had died of puerperal fever and Kolletschka developed symptoms of blood poisoning which were very similar to this disease. And suddenly Semmelweiss understood. The disease was contagious and was brought to the mothers by their attendants. This explained another remarkable fact. There were five times as

many mothers dying in the First Maternity Division, in which medical students assisted, as in the Second Division, in which the assistants were pupil midwives. The pupil midwives attended no post-mortems: the medical students both attended and conducted these. And as they were alternately examining women recently dead of childbed fever and delivering others of their children, they were continually carrying the contagion from the post-mortem room to healthy uninfected women.

* * * *

Semmelweiss, of course, had no idea as to the nature of this contagion: the idea of living organisms as infective agents was not introduced until many years later. But in spite of this, and amidst great opposition from his medical colleagues, who refused to believe that they themselves were responsible for the deaths of hundreds of women each year, Semmelweiss insisted that the medical students should frequently wash their hands in chloride of lime. This was started in May 1847. In April of that year, 18 % of the women in the First Division died; in May, 12 %; by the end of the year the mortality was 3 % and in 1848 it had fallen to less than 2 %. But Semmelweiss was before his time; the opposition and jealousies of his colleagues and chief drove him from Vienna to his native Budapest. Here, as obstetric physician to the hospital, he was able in six years to reduce the maternal mortality to less than 1 %. Semmelweiss died in 1865—just as his colleague had done twenty years previously—of blood poisoning from a wound in his right hand.

* * * *

There were others, too, at that time who cried aloud that puerperal fever was a contagious disease, carried to the patient from other patients by her attendants, the midwife and the doctor. In 1843, thirteen years before the beginning of *The Autocrat of the Breakfast Table*, Oliver Wendell Holmes, then a brilliant young surgeon, wrote a scathing essay on "The Contagiousness of Puerperal Fever". But, like Semmelweiss, it was in vain. His exhortation met with scorn or, worse still, was completely ignored by his contemporaries.

About twenty years after this, Pasteur, having found that bacteria were the cause of many animal and plant diseases, began to turn his attention to the role of bacteria in human disease. He found that these organisms were present in boils and in bone abscesses, and his suggestion that they might play a considerable part in the causation of human disease led Lister to introduce antiseptic measures into surgery in 1865. And when Pasteur later found the chain-like streptococci of puerperal fever, the contagion theory of Semmelweiss and of Holmes was triumphantly vindicated.

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Fifty years ago, the mortality of childbearing in England had fallen to 5·5 per thousand births—2·5 due to puerperal sepsis. In fifty years, therefore, the mortality had been halved. By 1900 it had fallen to 4·5 per thousand, with 2·0 per thousand

due to puerperal sepsis. The fall since then has been slower, and there has actually been a slight rise during the last ten years. We do not really know the reason for this, nor for the difference in mortality rates in different countries. For example, Germany and the United States have a decidedly higher maternal mortality than this country, while France and Scandinavian countries have a mortality not much more than half ours. But in each country about the same proportion of these women—nearly half—die from puerperal fever.

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Much important work has recently been done in an attempt to reduce the risks of this disease. A great deal of it has been done by Leonard Colebrook and his sister Dora Colebrook, working at Queen Charlotte's Hospital in London. In the first place, it was very important to determine the source of the invading bacteria in puerperal fever. Many doctors insisted that, in spite of our knowledge of the cause and our care in attempting to avoid introducing infection, the virulent bacteria were still often brought to the patient from the outside. Others, however, were of the opinion that some women carried the bacteria in their own tissues. These might gain a hold and cause infection during the strain of childbirth, and so infection which occurred in these women might be inevitable.

The Colebrooks found that in practically every case the organisms were not in the mother's tissues at the onset of labour but were conveyed to her. And, moreover, the bacteria need not have been brought from other cases of childbed fever. They were more often present in the throats of the attendants, who might have a sore throat or even an ordinary cold. And stranger still, in very many cases, they were present in the throat of the woman herself. That this has only recently been realized is shown by the fact that a very large British hospital had early in 1936 an outbreak of fourteen cases of puerperal infection, of which four died. And there was at the same time an outbreak of severe sore throat with virulent streptococci in the staff of the hospital. Only since then has the use of face masks been compulsory in this hospital. There is to-day probably no maternity hospital in England where face masks are not used as a routine.

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Leonard Colebrook was also responsible for a very thorough investigation into the antiseptics used in midwifery. He smeared the haemolytic streptococci of puerperal fever on to his hands and then washed them in various preparations. He found that the disinfectants commonly used, such as lysol or corrosive sublimate, always left a few live bacteria on his hands. Moreover, the antiseptic effect soon wore off, so that if more bacteria got on to them, they were not killed. But one preparation which he used, dettol, not only killed all the organisms but left a protective film on the hands which would kill any stray bacteria that might fall

on them. Since then dettol has been used in many maternity hospitals, and Colebrook says that since the introduction of this antiseptic for routine examination in Queen Charlotte's Hospital the number of cases of infection with haemolytic streptococci has fallen by 50 %.

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The fight against childbed fever has so far been a fight of defence. And the results of these methods in decreasing the risks of infection are striking. As we have seen, a hundred years ago women were much more likely to die of childbed fever in the hospital than in their own homes, and in Semmelweiss's clinic in Vienna, women prayed to be sent home rather than be admitted to the First Division where they knew that one out of every six or seven of them would die. Nowadays the incidence of puerperal sepsis in a modern hospital, with its full antiseptic preparation and technique, is often less than half that in the home. But however well a woman is guarded against infection, it is unlikely that the disease will ever be completely eradicated. The more effective use of face masks and antiseptics might result in fewer deaths due to infection, but there are so many possible sources of infection that it is impossible to foresee and combat all of them. So that the problem always exists of treating the infection which prophylactic measures have failed to prevent.

Until very recently, attempts at attacking the disease once it had gained a hold were not very successful. Serum treatment, which has proved so useful in diseases such as diphtheria, has been used extensively; but a very careful analysis of cases with and without serum treatment, conducted by Colebrook three years ago, showed that it was valueless. Similarly, operative treatment cannot be lightly undertaken, since the operation itself is a very serious and difficult one.

At last, however, we have at our disposal a weapon of true and proved value against the active disease. A drug has been discovered, called *prontosil* or sulphanilamide, which is able to attack the haemolytic streptococcus after it has entered the tissues and even when it is actually growing in the circulating blood. The drug was first tried out on animals. Twenty-six mice were infected with haemolytic streptococci; twelve of them were given prontosil and fourteen were not. In 3 days thirteen of the untreated mice were dead and the last died on the fourth day; the twelve treated mice survived. Then Colebrook began to use prontosil in cases of puerperal fever in Queen Charlotte's Hospital, and in June 1936 he published his first results. Thirty-eight mothers suffering from puerperal infection were treated with prontosil. Of the same number of cases immediately before this treatment, ten had died. But of the thirty-eight treated cases only three died. It looked as if the drug could destroy the streptococcus in women as in mice. Three of the cases treated had shown a spreading peritonitis which is nearly always fatal—all three had recovered. And in all of the women who had recovered, the temperature had fallen and the symptoms improved with amazing rapidity.

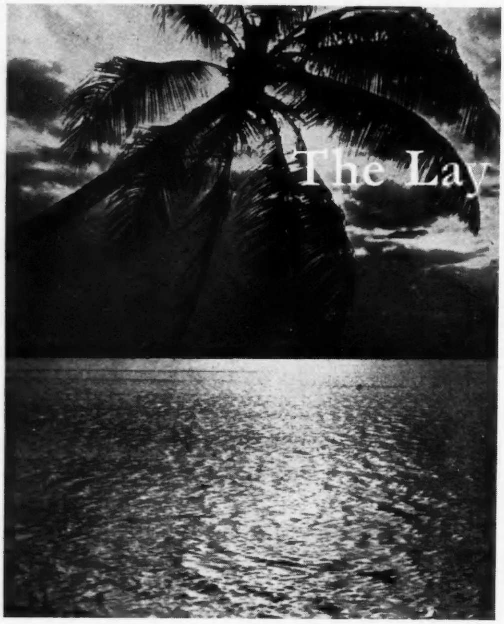
By the end of 1936, twenty-six more cases had been treated—with not a single death. And by the middle of 1937, Colebrook was able to report on a total of one hundred and six treated cases. Of these nine had died, making a mortality of 8 %. Before the introduction of prontosil, the mortality had been 24 %. Twenty-two of the women actually showed septicaemia, that is the haemolytic streptococci growing in their blood, a condition which is usually fatal in about three-quarters of the cases. And yet only six of these twenty-two women died. Before the drug began to be used, it was fairly common for the infection to spread widely in the body of the sick mother; and even if they eventually recovered, they were ill with a high temperature for a week or more, and the average length of stay in the hospital was 31 days. After prontosil was introduced, the spread of the disease occurred rarely and only slightly, the temperature fell rapidly, and the patients were able to leave the hospital after an average stay of 20 days. And the lives of two out of every three mothers suffering from the terrifying childbed fever had been saved.

* * * *

Many other workers have since been able to confirm the efficacy of this new weapon against death. In a Glasgow hospital seventy cases occurred or were admitted in a period of 3 months. Twenty-two were seriously ill and were given prontosil. Of these eleven had septicaemia and three had a spreading infection. Soon after treatment began, the temperature fell with extraordinary rapidity, and other symptoms such as rashes and swollen joints disappeared in a few days. Only one death occurred. The previous mortality figure for this hospital was 13 %, that is, of these seventy cases one would have expected nine deaths.

Although the properties of prontosil have been known for less than two years and its general use has only just begun, statistics are already beginning to show the effect of the treatment of childbed fever with this drug. The average mortality due to this disease in London between 1930–35 was 1·6 per thousand births. In 1936 it had dropped to 0·75 per thousand births—less than one-half. We may confidently expect that the general maternity mortality figure for the country will fall from 4·4 to less than 3·0 per thousand births, a saving of hundreds of lives each year.

JOHN YUDKIN.



The Lay of a Turtle

By EDWARD SAMUEL

IN common with many other places, turtles abound on the Queensland coast inside the Great Barrier Reef. There are three varieties—the loggerhead, for which no use has yet been found; the green turtle, edible, and famed for soup; the hawksbill, which provides the tortoiseshell of commerce.

At the southern end of the Reef, among the Capricorn Group of islands, is a noted hatchery of the green turtle. There, on one island, a cannery has been working, making the soup which is exported. A turtle corral has been built on the island where surplus turtles are kept until they are wanted for killing. Incidentally, the killing represents a stupendous waste. Only female turtles are captured and killed, and these are taken when they come up on the beach to lay their eggs. The male turtles do not leave the water. This continuous slaughtering of the females must have an effect in time, although to date the numbers are not noticeably diminished. There may be favoured areas where the hawksbill lays its eggs, but I have never found them.

The loggerhead adopts certain islands, monopolizing none, and only female fancy seems to indicate the time to dig a nesting-hole and lay. The turtle, at any island in the Whitsunday Group, finds a spot which suits her on a sandy beach, and there she does her duty to her kind.

The green turtle makes a bigger nest and lays up to two hundred or more eggs at a sitting. The loggerhead, though a bigger turtle if anything, makes a smaller nest and lays but about fifty eggs. The eggs of both species are perfectly round, covered with a leathery skin, bigger than a ping-pong ball, and white. When laid, they are covered in by the mother turtle and left to incubate in the bed of sand. Incubation may be any period of about six weeks. Dry weather seems to retard the hatching. Storms of rain and electrical disturbances advance the period a week or more.

Come with me, and on South Molle Island, in the Whitsunday Group, a portion of the Barrier Reef, let us watch a loggerhead while she goes about her business of life and obeys the biblical instruction to increase and multiply.

The mating period commences early in October, with the first turn of the summer tides, and when the warm water stirs the cold blood of the turtles. During December, and on to late January, a female turtle may waddle up the beach, sigh, seek a suitable place, and leave her eggs to what Fate has in store for them. Usually, and almost invariably, she leaves the sea at high tide during the night. Occasionally a female turtle

comes up during the day, when, prompted by urgency, she cannot wait for the night tide. Only twice has it been my privilege to see a day-laying turtle actually deposit her eggs. I shall describe one of these rare occasions.

It is about five o'clock, with the tide at the full, and the sun has hidden behind the western hills and is throwing long shadows. A fragment of a dark cloud, which may be nothing other than a shade, drifts through the water. It comes in closer and shows itself in the form of a turtle. It lifts its head where the ripples break on the beach, and, with a whistling exhalation and a sigh, it looks about before braving the dangers of the land.

Here is an old loggerhead turtle, a female great with life and with the desire to deposit her eggs—a monstrous oddity, she comes waddling from the sea, lifting herself forward with great lunges, making a trail which a Ford tractor might envy. Her horn-rimmed jaws let us know that she is a loggerhead—armoured and with the strength to snap off a man's arm at the wrist did the fit strike her—and her carapace differs from that of the green turtle.

The green turtle's shell is one regular sweep and has an unbroken edge. The loggerhead has what may be likened to a small verandah running right round the shell—an even projection an inch or more in width—and in addition the edges of the shell are serrated, like those of a saw.

Our prehistoric monster continues to heave herself forward, ignoring everything, refusing to be disturbed or turned even by the presence of man. She has but a single-track mind, and every sense which comes from her pin-head brain is centred on the great object of laying her eggs. Thus we are enabled to take liberties.

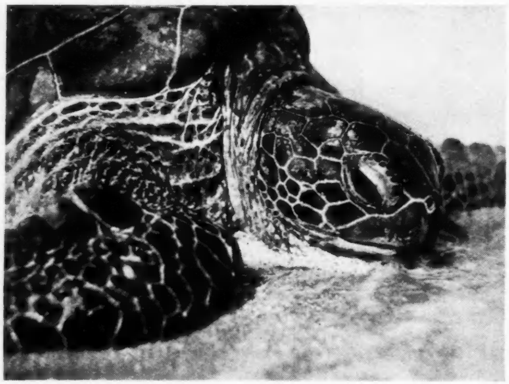
Odd barnacles and other forms of parasitic marine life adhere to her shell; if they inconvenience her, she gives no sign of it. She sighs continuously in great gusts, and jelly-like tears stream from her eyes.

The turtle reaches the high-tide mark, goes inland a few feet farther and tests the ground beneath her, cupping one hind-flipper and sending it probing for samples of sand in which she may dig. There is something about that place which lacks appeal; something there, perhaps, which should not be there; she leaves the beginning of a hole and looks for a more suitable spot.

She finds another place, one of half a dozen perhaps. A tentative hind-flipper scratches gratingly, a handful of dirt is scooped up, every grain of it held in the spoon-like depression formed in the flipper. She nestles closer to the ground, spreading

Aborigine astride a turtle. This shows the size of the animal, and recalls the story of de Rougemont.

over it, gripping it almost as an octopus is supposed to do. Her huge shell measures 42 in. from neck to breech, and we are ignored as we run the tape over her. The shell is 38 in. across, allowing for the arch; 108 in. right round the circumference; 28 in. across the belly; and the body, from belly-plates to the arch of the carapace, is 11 in. deep. She weighs anything from 200–300 lb., and her age is beyond man's computing—maybe a couple of centuries back our turtle made her gay debut as a young flapper.



Head of a Turtle.

The old thing seems to have found the place that suits her. She digs. She continues to dig. She sighs. She grunts occasionally. And while we watch, the hole she is digging grows in depth. She ignores everything; a man may jump on her back; a dog in its eagerness may scratch at her carapace with its paws and attempt to bite the back of her neck; nothing matters—she has a job on hand and she attends to it. Her eyes are out of range of her work, and she must carry on by blind reckoning, aided by instinct. Then, when the work has commenced in earnest, the turtle brings her tail into play. It probes, feels, gauges, judges distance, does all but see; and it appears to be as handy as a socket wrench and a carpenter's three-piece rule combined. It is a mite of a tail, about 4 in. long, prehensile as an elephant's trunk, sensitive as a blind man's finger-tips.

The turtle grates with the hind-flipper on her right side, forcing it down just as a man would work a blunt shovel into the earth. She curls the end to form a hollow member and lifts the loose earth to the surface. She sighs, while great tears roll down her cheeks. She gives a slight jerk and a heave and shifts position to bring the left flipper over the work. She goes down with it, hollows out the dirt and lifts it to the surface.

The work, though systematic, isn't regular. The right flipper lifts the earth and deposits it in a heap. The left brings its load to the surface. When shifting position to swing into shape for a new delve, she gives the left flipper a twitch, and that shoots all its loose earth across to fall on top of the mound formed by the right flipper. The work continues. Between each change of position the turtle pauses while she lifts her head and sighs, sucking in her breath and exhaling. And the peculiar feature of her respiration is that, though the old creature is on dry land, with good air all about her, she adopts the same position to breathe as when afloat on the ocean. And, all during the digging process, while earth is being excavated and tossed about, that busy-body of a tail is on the job all the time. It is testing, passing, condemning, probing, with inquisitive pragmatism searching for a fault.

The hole goes down, a perfect post-hole in its sinking, and about 8 in. in diameter. It reaches a depth of about 10 in., and the flippers stretch telescopically from the hips as she reaches to touch the bottom. Almost one might imagine the strain of the stretch as the turtle lengthens the last inch or more that she has in reserve, and the loose trousers of skin tighten at the hips and shine at the knees. She takes longer periods between each shift of the body and the probing flipper sent below, and in her

weariness she seems to sigh more heavily from her labours.

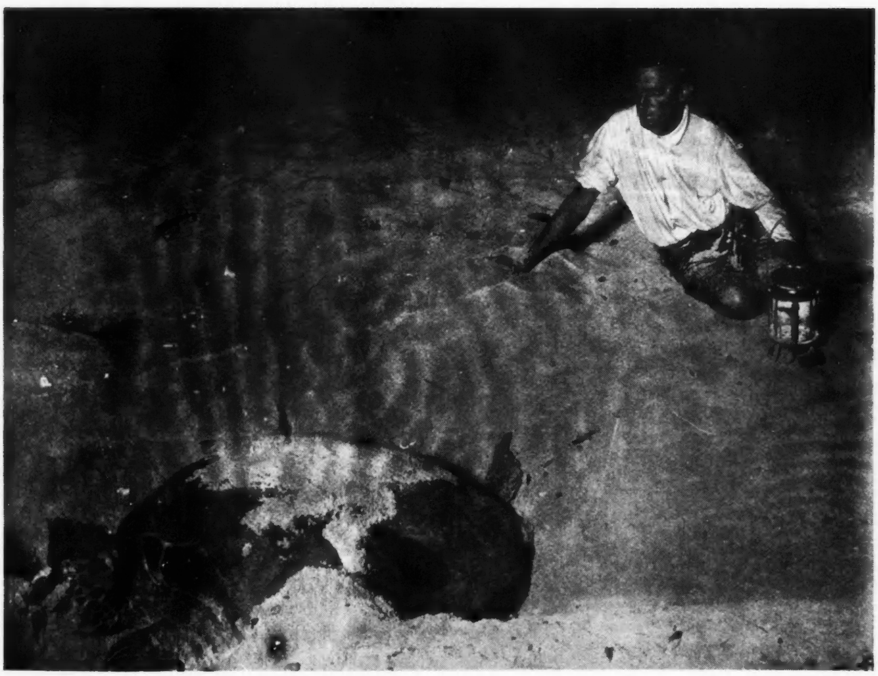
The tail is as busy as before, still striving to find some fault and to tell the owner some work must be done afresh. Though the loads are diminishing in quantity as she brings them to the surface, that inquisitive tail is as keen on the job as ever and inspects and passes every move. She keeps on going down-down-down, until her stretched hind-flipper can but grate on the bottom and bring up the equivalent of a teaspoonful of earth after each delve below. She is down 14 or more inches, in a hole perfectly dug and with the loose earth neatly piled on top on the right-hand side.

For the space of 5 sec. or more, the turtle lies over her hole, her eyes streaming, her body heaving with great sighs. The tail makes one final survey, and then, its duty done, it is absorbed into the ovipositor as that is lowered into the hole—a tube-like trunk almost as thick as a man's wrist and a foot or more in length.

The turtle sighs, steadies herself, and with a final tautening of her muscles a swelling appears in the egg-tube that we call the ovipositor. The swelling slips down the length of the tube, and a new-laid egg, glistening white, wet with mucus, an outsize in ping-pong balls, rolls into the bottom of the hole.

With but a momentary pause, another swelling appears, slides down the tube, and another egg joins its fellow. Another comes —another and another, and, when the tide has turned and the run has commenced, they come singly and in pairs, threes, and roughly at the rate of nine a minute.

"Forty-three. Forty-four. Forty-five."



Scientist watches a turtle preparing to lay.

The hole is almost full, and the top of the ovipositor, like the end of an elephant's trunk lying on the ground, nestles lovingly over the eggs it has shed. They lie in an orderly heap, piled on top of one another, and all wet with mucus.

The Lay.

"Forty-six. Forty-seven." And then, the turtle sighs and with a last effort lays her final egg, "Forty-eight".

The job is done—forty-eight young loggerheads in embryo have been put into the earth to hatch out by the heat of the sun on the sand.

This female creature of the sea, seemingly spent, lies there and sighs while globules of tears course down her cheeks. It seems that she is taking a breather after her efforts. That busy worker, the tail, again shows itself as the ovipositor is absorbed into the turtle's body.

The turtle twitches with her right flipper. She curls it about the mound of earth that she has built. With startling suddenness for so huge a body, she shifts smartly to the left, and as she moves she sweeps with the flipper. And, in that raking movement, the whole of that prepared mound of earth, and with it any loose dirt lying on the surface, is swept into the hole and fills it.

That is neat, prompt, business-like, and effective. Her labours seemed finalized in one action. That, though it might suit us, isn't according to the turtle's book of ethics. She has to guard her nest by hiding its site.

First she presses both hind-flippers on top of the place where the hole has been. With almost the same action as that of a baker kneading bread, she squeezes backwards and forwards, from right to left, diagonally and in circles. She presses the earth back into shape and hides the spot at which she has dug. Even that doesn't satisfy. She rakes with her fore-flippers; she scratches with the hind ones; she throws up dirt in billowing waves; and she indulges in dry-land swimming for fully a quarter of an hour.

When that final rite is complete, the earth is torn up over an area that has a diameter of 20 ft. or more. The site of the nest is hidden to her satisfaction. Without so much as one final look backwards the turtle turns to the sea, and leaves her eggs to follow the course which Fate has ordained for them.

What of those eggs? As there are no dingoes on the islands, they are immune

Young turtle just hatched.

from that form of attack. But goannas possess a weird sense that enables them to locate turtles' eggs. They are particularly fond of them. Human beings might interfere with them—and the aboriginal is extremely partial to turtles' eggs. Anything might happen to them.

When incubated—and I have made careful observations—the young turtles gather together in the sand and stay there for an approximate period of three days. This may be so that late hatchers may join the main body and all may go together. It also might be so that the little fellows may find their legs, as it were, and also that the umbilical sac of nourishment may have time to be absorbed into the body. (A turtle freshly hatched invariably has the sac appended. One fresh from the nest and making for the sea invariably has perfectly smooth belly-plates.)

When fresh from the egg, a turtlette isn't inconvenienced at all by being turned on its back. It just wriggles and turns over as naturally as any other baby. When a month old, and from that on until it is gathered unto its fathers, a turtle turned is a turtle helpless.

We left those little fellows clustered together under the sand and waiting to break for the sea. Left alone, the call will come to them at night, and they will disappear under cover of the darkness. If the nest is disturbed near that time, the infant minds will think that disturbance is made by mates travelling. In a flowing stream, pell-mell, falling and tumbling, picking up and recovering, in a rush the young turtles will pour from their home and make for the ocean. And, having escaped all other dangers, what then? Most of them die —as fodder for hungry fishes, from a thousand other causes, and by several other means. It has been estimated that only one young turtle out of many hundreds ever reaches maturity, and comes sighing up on the beach to dig holes in the sand in which to deposit its eggs.

Notes of the Month

AT present, physical research is concentrating most intently upon the *nucleus of the atom.* We know a great deal about the arrangement of the electrons in the outer parts of the atom. Until the last year or so, however, the structure of the nucleus has remained almost as mysterious as in 1911, when Rutherford first established its existence. Within the last few months, Bohr has put forward a new explanation of the nucleus. This new idea has already explained some of the most puzzling facts. It is not easy to communicate in a few words, but a full length description will appear shortly in *Discovery.*

Niels Bohr is a Dane, and occupies a unique place in modern physics. He has published less than many of the great living theoretical physicists; but they have all attended his Institution at Copenhagen, and his genius has appeared in many other men's work. "There has been nothing like it since Socrates", someone once said. History may not realize how much science owes to him.

His own most famous contribution rests in his theory of the *nuclear atom* (1913), which was a complement to Rutherford's experimental proof. They both showed how the atom consists of a heavy nucleus and electrons revolving round it like planets. For twenty years theoretical physics concentrated on, refined, and solved this problem of the planetary electrons in the atom. It is only now, twenty-five years later, that we are gaining much light on the structure of the nucleus. Once more the original idea is Bohr's. (Bohr, Copenhagen.)

* * * *

The brightest objects yet known were discovered last summer. One *supernova* flared up on 31 August, and another on 10 September. Both are about 500,000 times brighter than the sun. They are millions of light years away, and were only found by a telescopic survey. A supernova is due to some unknown catastrophe within a star, which suddenly bursts out into this extraordinary brightness and in a few days fades away again.

It is thought by some physicists that these stellar catastrophes are the source of "cosmic rays". Cosmic rays come from outer space with the greatest energy of any radiation that hits the earth. When they arrive at the top of the Jungfraujoch, for example, they are able to knock pieces out of the nuclei of atoms. This experimental evidence (obtained by the very simple method of leaving photographic plates on the top of the mountains) gives strong support to Bohr's new theory.

(Supernovae—the two recent ones, discovered by F. Zwicky, U.S.A.)

(Jungfraujoch experiments, Blau and Wambucher, Vienna. Explanation of the Jungfraujoch experiments, Werner Heisenberg, Germany.)

In the earth's atmosphere, argon is much more plentiful than neon—another inert gas, well known nowadays for its use in the bright-red illuminated signs. In the sun, neon is much more plentiful than argon. Apparently the atmosphere must have lost most of its neon when the earth was very hot.

These gases are also contained in granite in the earth's crust. Lord Rayleigh has just measured their relative abundance here: he shows that the preponderance of argon is much reduced. This, of course, suggests that there has actually been a loss of neon from the atmosphere. (Rayleigh, England.)

* * * *

The study of nutrition, both in animals and human beings, gives odder and odder results. Australian sheep show several well-marked diseases directly due to malnutrition. They live in a country of apparently good grazing land. But, however well they eat, they still show the characteristic anaemia of under nourishment. It has now been shown that they are almost immediately restored to health if they are given minute amounts of a soluble salt of *cobalt*.

(Marston, Line, Thomas and McDonald, Adelaide.)

* * * *

The two following notes have been contributed by DR RABEL, *Vienna.*

Dr Hans Tollner, of the Vienna Meteorological Observatory, who was invited by the National Union of Students of England and Wales to accompany them to Spitsbergen, profited by this opportunity to try out an automatic recording instrument which he had constructed. It was the first time that a device had been built for the purpose of registering the movement of glaciers.

The opinions of scientists have been divided as to whether glaciers stream evenly or in sudden pushes. Tollner's instrument shows that both parties are right. There is a slow continuous movement and there are dislocations up to as much as four inches within a few seconds. These jolts might possibly be connected with what is called in German the "calving" of glaciers. When the end of a glacier tongue extending into the sea is broken off by the water, the sudden relaxation of the pressure from below might cause the higher parts to glide down.

The motion of the ice is rather complicated. Apart from the sloping towards the lower end of the glacier and apart from a vertical component ascertained by R. Finsterwalder by means of the photogrammetric method, Tollner's photos show a lateral movement which indicates vortices (turbulence) in the ice. This also explains the fact that the vertical component had been found to be directed downward in the midst of the glacier and upward at the edge.

Other observations of Tollner's led him to the conclusion that pulsation of glacier tongues up to almost twenty per cent of their length might be explained by changes in the air temperature. In the Alps he observed a distinct daily period which seems to be connected with the daily curve of the thermometer. Increasing temperature causes the ice to become more plastic and accelerates the motion.

Tollner was also able to explain the so-called "Kryokonit" tubes—long parallel tubes richly dispersed over the arctic ice. Dark minerals lying on the surface act as "black bodies". They concentrate the heat in their neighbourhood, melt the ice around them and thus sink below the surface. It was, however, hitherto maintained that only shallow pits (called dust wells) can originate in this manner, because the radiation of the sun cannot penetrate farther through the ice. The Russian Kalitin, on the contrary, found that as much as 60 per cent of the radiation can intrude as deep as 90 feet below the surface, and that also direct sky light contributes to the melting process. From these measurements Tollner computed that the deep cylinders observed in the arctic originate in the same manner as the shallow pits, the "black body" sinking deeper and deeper. A condition for this phenomenon, it is true, is a certain structure of the ice which is found in the arctic region but not in the Alps. Where this structure is present, Tollner succeeded in producing artificial Kryokonit tubes by placing minerals on the surface of the ice. Where this structure is absent, only shallow funnels or craters originate instead.

Perhaps we shall gain new information on these matters from Dr Seligman's English expedition to the Jungfraujoch, the chief purpose of which is to study glaciers.

* * * *

A pholas mussel is a meeting point for all kinds of little animals. Among others a small crab, *Alpheus dentipes*, often finds shelter in this situation. When a zoologist has cleaned out the mussel and lodged the inhabitants in glass vessels, it may happen that he suddenly hears a detonation, as if the glass had exploded. But on closer examination he will find that it was the little crab that shot. These crabs live in tropical districts near coral reefs, and travellers often hear them shoot. Some say it sounds as if somebody had struck a wooden ruler on the edge of a basin. Seventy years ago this strange noise was described for the first time, and many theories have since been advanced to explain it. One of these theories compared the phenomenon with the opening of a bottle of champagne, because actually the claws of the crab consist of two pieces which fit into each other as the cork into the bottle; it was thought that every opening of the claw caused this noise. But this requires that the claws should have a hermetical closing, and according to Dr Peter Volz this is not so. As Dr Volz told the Zoological and Botanical Society of Vienna, his own studies showed that the explanation goes the other way. The crack does not occur when the crab opens its claw, but on the contrary when it closes it. At this moment it presses a quantity of water through a kind of gun-barrel and thus shoots out a current of water, which prevents enemies from approaching. Volz considers this shooting as a threatening gesture, although the noise itself is probably not heard by crabs. When another male comes near, the crab first stands upright on its feet and waves its claw. If this is not enough to frighten the enemy, the water pistol is put into action.

Polar Exploration and Arctic Navigation

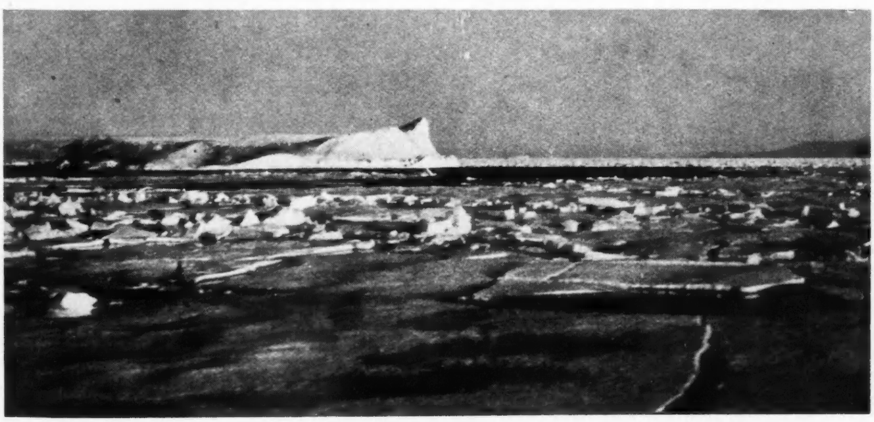
By B. D. Orris

(Dr Orris describes how Arctic exploration has attracted adventurous men for over 2000 *years. The photographs are mainly due to the Russian expedition of* 1937–8, *the latest and most thorough of all those feats of courage and endurance.)*

THE first reliable records of a systematically planned voyage of exploration into the Arctic regions date from the year 320 B.C. It was then that Pytheas—geographer, mathematician, and scientist—set out from the Piraeus with two ships, touching at his birthplace Massilia (now Marseilles), on a journey to the Island of Thule, which is known to have played its part in the history of German exploration in later centuries. This Island of Thule was most probably the Iceland of to-day. At any rate, we gather from early German chronicles of navigation that the islands off the Norwegian coast were meant, probably the Lofoden Islands and others. It is established as fact, however, that Pytheas penetrated as far as Iceland with his two ships, and from there he took observations about the height of the Polar Star. Moreover, Pytheas struck the "dead water" mentioned in German descriptions—the regions of complete calm that were extremely advantageous to the shipping of that time. That he should have encountered the vessels of Vikings can be rejected as an anachronism. Nevertheless, his two ships, on their return to Massilia where Pytheas was to spend the rest of his life, brought back with them material for the first descriptions of the Germans on record.

* * * *

When Horace and Tacitus later mention the "Hyperborean Ocean", they mean the southern part of the Frozen Sea to which other seafarers after Pytheas—among them the Genoese Liborio and the Greek Paipos—had later penetrated. We can really speak of an organized Greek and Italian navigation of the Arctic regions up to the time when military developments and the in-

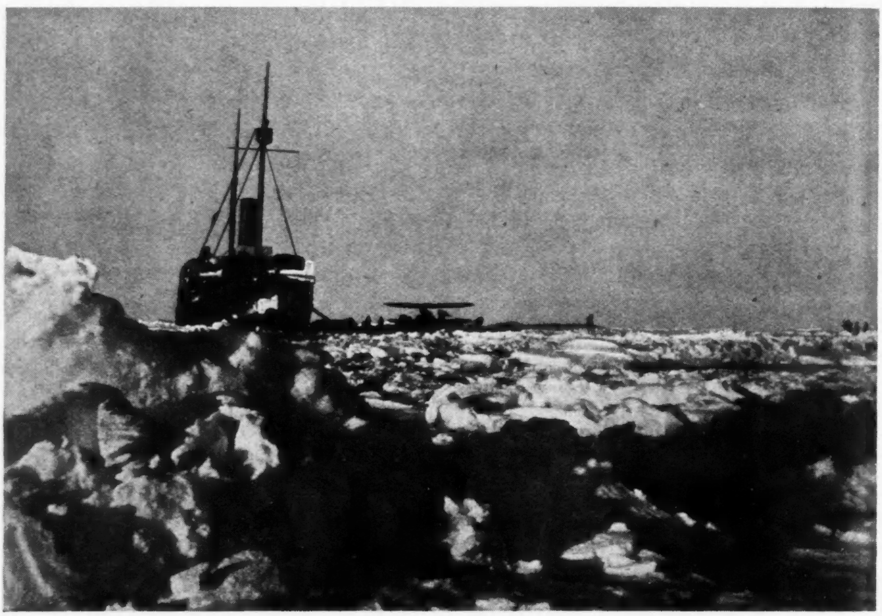


Pack Ice in the Arctic.

creasingly tense situation at Rome distracted interest away from voyages to places so distant, which still had very meagre results to show for the vast exertion and frequent losses in men and ships that had been expended. At all events, Horace and Tacitus still speak of the lazy North Sea which lay at the end of the world and in which water, air and sun finally mingled in such a manner that all motion was impossible at the point where they met. If the ships of navigators disappeared on these journeys, it was always taken for granted that they had plunged "into eternity from the edge of the icy sea, the Hyperborean".

* * * *

It was the Vikings who put an end to the fairy tales about the Arctic lands and seas. About 200 B.C. they had already made fairly exact charts of the groups of islands near Norway and north of the British Isles. They also brought these maps to England, where they were used as early as the time of the Roman domination. When the Romans had established themselves firmly in Britain, they sent out ship after ship in order to take possession of the islands north of Scotland, but, strange to say, very few of these ships ever returned. A great deal is heard of battles with brave seafarers off the coast of Iceland, but there was probably truth in the remark of Bishop Eirin, who, as second Prince of the Church, was transferred to "Papey" (as the Eskimos still call Iceland), when he expressed the view that these same Vikings, Danes and Norwegians, whom the Romans cunningly invited into their harbours to profit from their information, probably destroyed the Roman ships in those mysterious waters with which the Vikings were quite familiar. At any rate, Anglo-Roman polar exploration was completely abandoned after about a century, apart from isolated attempts by particularly bold Romans, who, however, all mysteriously perished.



Icebreaker making its way through ice. Eric the Red was imprisoned for months in such ice floes, on his expeditions in the tenth and eleventh centuries.

Fissures in the Pack Ice (the Russian sailor is jumping one out of high spirits).

Later the Irish were to distinguish themselves by the conquest of Iceland and Greenland. The Irish monks, who came mostly from noble families, often could not endure the quiet life of the monasteries and left the "Emerald Isle" to push off energetically towards the north and north-east. They went in sailing ships and rowing ships, which were particularly constructed so as to afford protection against the "Dead Water". On the way they struck Iceland about the year 795, and they settled down there after a hard struggle with the newly arrived Viking settlers. The conquered peoples returned to Denmark and Norway to make propaganda for a war against the Irish conquerors. In the first half of the eleventh century, a fleet of thirty-two Viking ships set out for Iceland, where they won a complete victory over the Irish settlers. After the latter had almost all been destroyed, the island was rechristened "Priests' Country", as a satirical reference to the people who had come and gone. It is certain, however, that the Church strove continually after the Norman conquest of Iceland to turn this island into a new support of the Catholic faith in the far north. In the year 992, a papal armada even undertook a voyage to Iceland, but it was compelled to take the road of "Eric the Red" towards the west. Iceland was to remain in possession of the heathen for some years to come.

* * * *

This Eric the Red, or Eiriki Raudaa, was the first navigator who realized that north of Norway and Sweden one must come to the land of the Finns, or other unknown eastern regions from which people at that time expected fabulous treasures. But his plans of exploration met with violent

opposition from the leaders and men of influence among his Icelandic tribe. After having slain two of them one day in a fit of violent anger at their backwardness, he had to leave Iceland for fear of the revenge that would inevitably have followed. This is said to have led to one of the most important discoveries in early medieval navigation of the Arctic, for in 983, Eiriki Raudaa was the first white man to land in Greenland. He is also supposed to have later—about the year 1010—penetrated from Greenland to the north coast of North America. The likelihood of the latter is questioned by many of our modern polar explorers—even Nansen rejects the supposition. It is certain, however, that Eiriki Raudaa welcomed the papal fleet to Greenland in the year 992 and that he supported the establishment of a Roman bishopric.

In the following decades the "Greenland knarre"—a boat with oars and sails and a crew of about sixty men—became a familiar feature of shipping. Its freight was chiefly walrus tusks and whale oil which were sold along the northern European coasts. It was in the form of these wares that one "knarre" brought "Peter's Pence" across to the Pope. It was a fleet of such vessels, moreover, that reconquered Iceland for Christendom when Eiriki's enemies had either died or departed again from the island.

* * * *

From the eleventh century on, we see the development of a regular shipping trade between Denmark and Norway on the one hand and Iceland on the other. However, the Normans soon left the inhospitable Greenland, so that it was always being "discovered" again at intervals. In other words, it was always having to be resettled. About the year 1200, we hear of one Adam of Bremen who organized systematic piracy from the Greenland coast and exercised a reign of terror as far down as the Scotch harbours. Only when England built a fleet of battleships was it able to keep at least the waters on the British coasts clear. The occupation of the Hebrides by Scotch battleships in about 1320 was a further signal that the glorious days of the Greenland freebooters were over.

* * * *

At any rate, it was to this irregular shipping traffic in the Arctic waters that the medieval navigators owed a great deal of important information about the conditions of the sea routes, the possibilities of developing the land discovered in the Arctic regions, and the influence of the different seasons on land and sea weather. It would probably have taken centuries for an officially controlled shipping to have systematically navigated those waters and made the observations for which the brave, if not altogether law-abiding, explorers and seamen of the eleventh, twelfth, and thirteenth centuries were responsible. Only later did Denmark and Sweden send their navies into these parts, and then a new period in the development of the Arctic began. This new period was distinguished by the continuous struggles between Denmark and Sweden, in the course of which the harbours of Iceland were to serve exclusively as camps and hiding places for the battleships of both nations. Whatever discoveries and improvements in the technique of exploration were made from the sixteenth century or almost up to the beginning of the eighteenth century can be put down to the crews of battleships. The almost incessant wars between the Scandinavian countries, England, France and Holland, in the course of which countries often changed sides, left no more opportunity for private navigation.

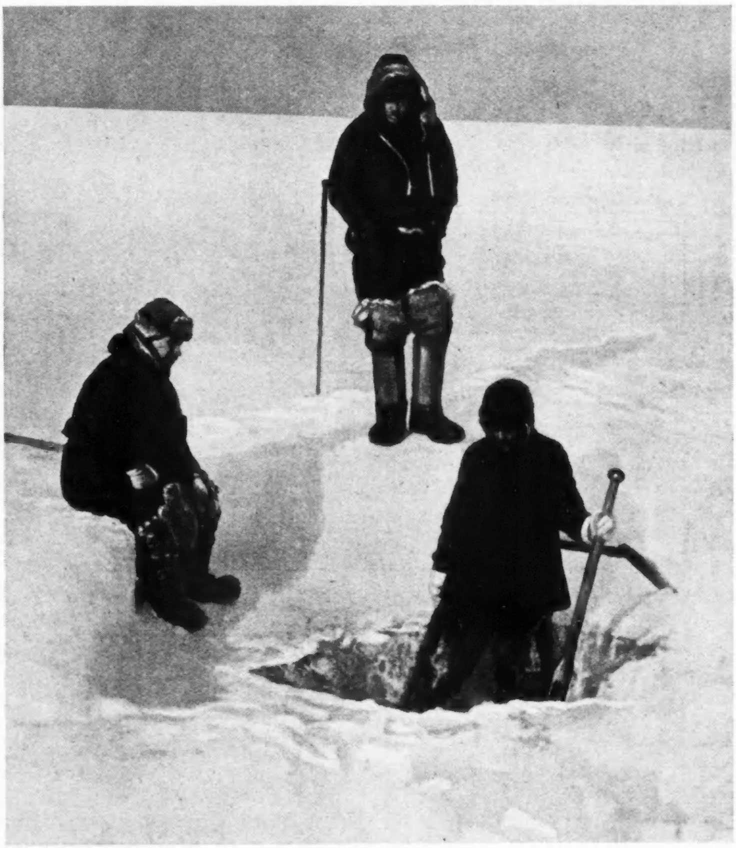
* * * *

Thus knowledge acquired several centuries previously was prevented from being put to the service of a new and progressive polar exploration, such as was developed in the nineteenth and twentieth centuries by people like Peary, Cook, Amundsen, Nansen and others. Only when they were completely convinced that the frozen coasts of the Arctic lands really concealed no "green land" with fabulous treasures (as was believed of Greenland, for example,

almost up to the year 1800) did the English, Dutch and Scandinavians abandon their struggles for this territory. The seamen, who clearly and definitely proved that the Arctic lands were unsuitable for settled habitation, did more for the peace of Europe than many a carefully worked out peace treaty.

* * * *

Since the appearance of the four explorers mentioned above, however, the aboriginal Eskimos have been brought more into contact with European civilization. The later type of European or American navigator of these parts is the explorer on his film ship who wants to bring the cultural relations between Europe, America and the Arctic lands closer and closer together. Perhaps this form of modern navigation, together with organized commercial undertakings, is better suited than the former kind of navigation to solve the last mysteries and the last riddles that cling about those regions situated around the "Great Needle", as the North Pole is called by the Eskimos to-day.



The North Pole Itself
(the explorers are Papanin, Frenkel and Shirshov).

The Torres Strait Natives

By Ewen K. Patterson

(*Mr Patterson is already well known to readers of* Discovery *as an authority on Australasian animals and natives.*)

THERE are many tropical islands scattered about the oceans, but few, if any, are as little known to the outside world as the islands of Torres Strait, that comparatively shallow stretch of water which separates North Queensland, Australia, from New Guinea. In the Strait lies a labyrinth of islands, large and small, ranging from a few acres to several square miles in area. Most of them are of volcanic formation, and are submerged ridges and peaks of the ancient land-bridge, which once connected Australia with Asia and now lies buried beneath the beautiful waters of Torres Strait.

Together these islands constitute one of the least-known portions of the British Empire to-day; they are rarely visited, despite the fact that they are endowed with an ideal climate and most wonderful tropical scenery. It is impossible adequately to describe their scenic attractions. They all have fascinating coral gardens, wherein many kinds of beautiful corals grow with a luxuriance not equalled in any other coral region in the South Pacific, and probably the world; they have delightful lagoons whose placid sun-kissed waters smile a welcome against a background of stately palms and other luxuriant vegetation; silvery beaches where gentle wavelets sing of eternal Spring; mountains grim and stern, with valleys cool and shady; bluff headlands and peaceful bays.

The artist would find enough material on the islands to keep him busy for months at a stretch, while the nature student, the sportsman and the fisherman would vote them paradises. Most of the islands swarm with bird and butterfly life, while some are overrun with wild pigs, wild deer and wild duck. Turtles and dugong also abound in the surrounding waters, where the variety of food and game fishes is infinite.

* * * *

The islands would undoubtedly make ideal tourist resorts, but the Government of Queensland, which has control of the islands, has wisely reserved them for the natives—the Torres Strait Islanders, whose ancestors first settled there countless years before the discovery of Australia by the white man.

Ten of the largest islands in the Strait are closed native reserves, prohibited to white men; these are Mer, Badu, Moa, Sabai, Yam, Mabuiag, Coconut, Darnley, Stephens and Yorke Islands, and on them dwell some four thousand natives.

No other islands in the Pacific have such a romantic history as these islands of Torres Strait. Not much more than fifty years ago the natives were fierce head-hunting cannibals, who cherished human heads, particularly the heads of white people, more than anything else. Many relics of those gruesome days are still to be seen on the islands. On one occasion the heads of forty-five shipwrecked white people were found on one of the islands. The skulls were all hanging on a large turtle-shell image, formed roughly to the shape of a human head.

Fortunately those days are past; the natives' blood lust has been completely eradicated, and to-day the former head-hunters live a happy, peaceful, and care-free existence at their picturesque settlements, which are among the finest and

most up-to-date native settlements in the world. The natives have not changed into imitation whites, as so many other Pacific natives have done. They are still natives, who, entirely of their own initiative, have developed native life to a very high degree.

Within recent years the natives have made extraordinary progress—progress which is well exemplified in the fact that they already have some £100,000 of their own money invested in Government Bonds, white-man fishing boats, and others are engaged in boat-building, farming, etc., on the islands. Unemployment is unknown on the islands, and more than 1500 of the natives have their own private bank accounts, with credit balances ranging up to £500.

Although each of the islands is under the supervision of a representative of the Queensland Government, the natives have their own unique form of self-government, while they even have their own unique radio service and newspapers!

Torres Strait Islanders turning out to welcome a visitor.

Despite this, they remain probably the least known of the world's civilized natives.

The natives are not Australian aborigines, and in them the characteristics of the Papuans and Melanesians predominate. Of magnificent physique, they have very dark brown skins, and thick woolly hair, jet black in colour.

The natives are born divers and fishermen, and they earn their living chiefly at fishing for pearls and pearl-shell, trochus-shell, beche-de-mer, and tortoise-shell. They possess a modern fishing fleet, valued at over £20,000, and this fleet's earnings average about £25,000 annually. In addition, hundreds of natives are employed on being the only subjective self-governed natives in the world.

Each island has its own "legislative council" or "parliament", which is composed of three councillors who are elected at a general election held every three years; all natives, male and female, over the age of eighteen years are given a vote.

The elected councillors have complete control of the domestic affairs of their own island; they are supplied by the Government with badges and special uniforms consisting of a pair of grey trousers, white panama hat, and a vivid red jersey with the word "Councillor" embroidered in large white letters across the chest.

The councillors hold meetings once a month, and they frame their own laws and

have their own policemen to see that the laws are obeyed. The islands have some unusual laws. They are one of the few parts of the world where the curfew is heard nightly. Every evening at nine o'clock a curfew bell is tolled, and any person caught out-of-doors after that hour is arrested by the policemen, who regularly patrol the islands. Dirtiness of home or person is also a crime, and this unusual law is responsible for the good health of the natives and the outstanding neatness and cleanliness of their picturesque palm-thatched homes; they are by far the healthiest natives in the Pacific. It is also a serious crime for anyone to take alcoholic drink to the islands.

All law-breakers are arrested and brought before the court, where the councillors act as judges. Each island has its own gaol and native gaoler, and the dusky magistrates have full authority to inflict punishments for minor offences, such as disorderly conduct, thieving, bad language, etc., ranging up to three weeks in gaol. Cases of a serious criminal nature, which are extremely rare, are referred to the white police.

This unique system of self-government has proved very successful, and so commendably do the councillors rule their islands that it is very rare for the authorities to have to interfere in any way with the native "parliaments".

The councillors also have control of the islands' revenue, which is obtained by means of an income tax of 5 per cent deducted from the net earnings of all natives in employment, and also from police-court fines, and from dog and gun licences. The money thus received is used solely for community services, while from a Provident Fund payments are made to old and sick natives incapable of working.

Extensive road works have been carried out by the councils, and the native villages to-day represent model suburbs. Where once the villages contained nothing but dirty grass huts, decorated with human skulls and other gruesome ornaments, they now have pretentious wooden and palm-thatched bungalows of three and four rooms, laid out in true suburban style, with beautiful gardens. The streets are also lined with gardens, palms and other luxuriant tropical shrubs and trees.

The natives have their own schools, which have played an important part in making the islanders self-dependent. In fact, the educational system on the Torres Strait islands is regarded as the finest and most thorough system in operation at any group of native settlements in the world.

For instance, what is believed to be the only training college for native school teachers in the world, is situated on Mabuiag Island. This unique college was established two years ago; it is under the control of a white-man teacher, and every year specially selected native boys and girls are sent there to be thoroughly trained, after which they are drafted to native schools on the islands. To date more than sixty teachers have passed through the college and are on the teaching staffs of native schools throughout the Strait.

Approximately 1400 children attend the native schools; they are taught to speak, write and understand English perfectly, as well as being instructed in other general subjects. The boys also receive tuition in horticulture, fishing and seamanship, including practical instruction in boat-building, ship-rigging, and so on, while the girls are trained in sewing, cooking, and other domestic work.

The natives also have their own trading stores, which are worked entirely by the islanders for their own benefit, all profits being used for their welfare.

Each of the islands also has its own church and native clergymen, who are products of a unique native theological college on Moa Island. At this college specially selected native boys are trained to become clergymen. Every year recommended pupils are forwarded to the college from the schools; after passing through the college these natives are first licensed as deacons and later are ordained as priests.

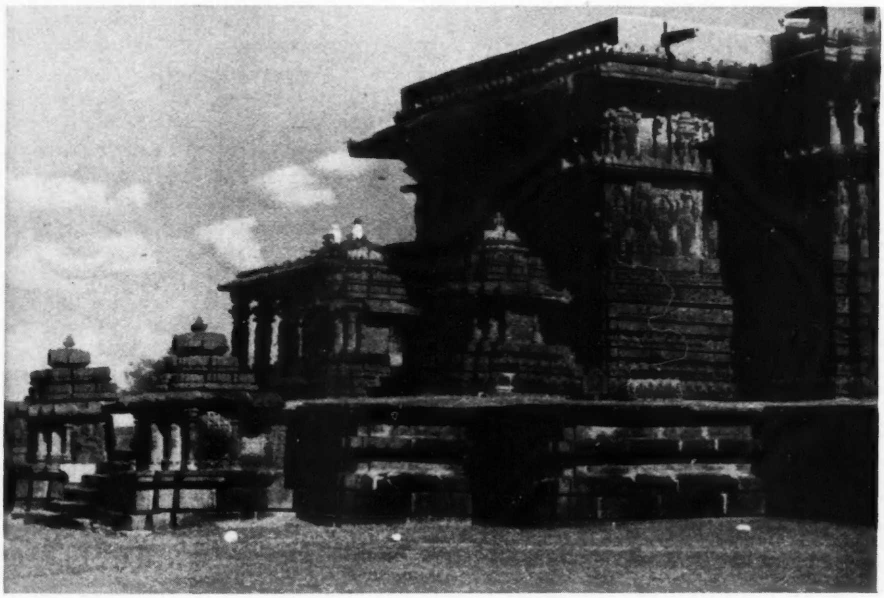
The natives also have their own type-written newspapers, while recently the islands have been equipped with a unique radio service—the first thing of the kind to be introduced to any group of native settlements in the world.

On each island is a wireless transmitting and receiving set, and these operate in conjunction with a "mother" station at Port Kennedy, Australia's most northerly port on Thursday Island. As a result of the radio, the islands (most of which are more than 100 miles from Port Kennedy) have a direct and speedy means of communication with the outside world, and the Queensland Government proposes at an early date to provide a seaplane at Port Kennedy for the purpose of making visits to the islands in time of sickness, or other emergency.

Mysore's Medieval Sculpture

Photographs by Frances Flaherty, Jun.

By **Winifred Holmes**



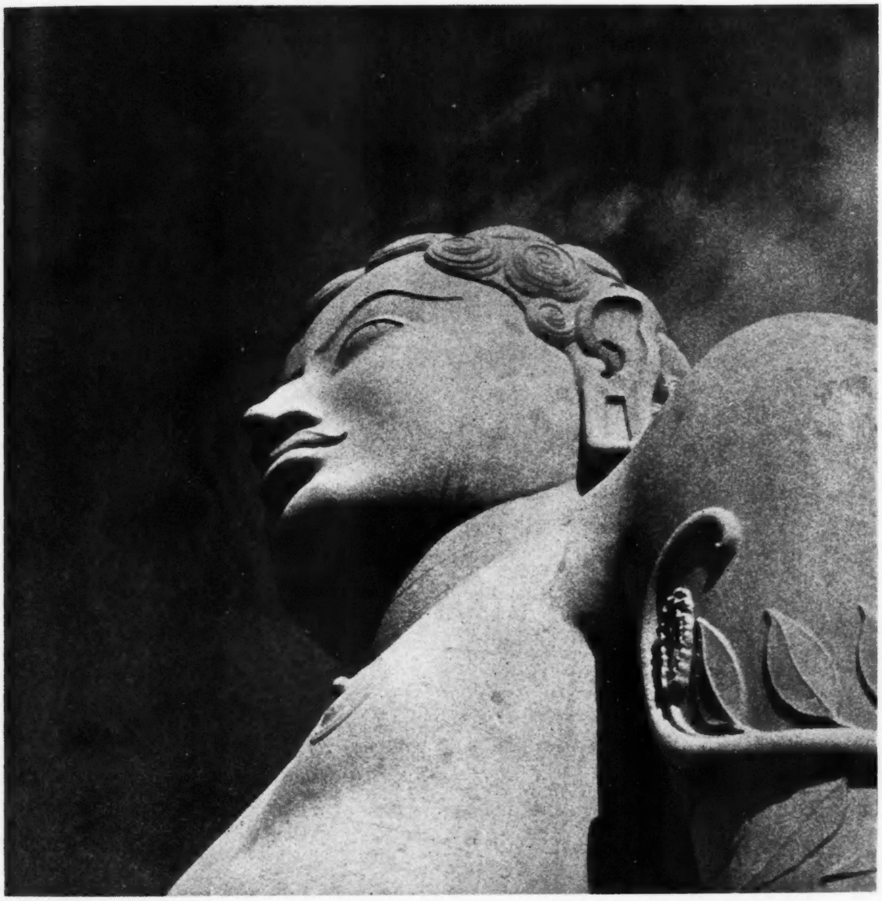
The Hoysala Temple at Somnathpur.

THE best way to approach the State of Mysore for the first time, and later to understand and appreciate the exuberance of its medieval carving, is to look down upon it from the escarpment of the Nilgiri Hills. There far below us is a vast sheet of bamboo jungle, broken occasionally by rocky hills sticking up sheer and melodramatic as fangs from the level green sea. Driving down the *ghat* road, through tea and cinchona plantations and Judas trees in rosy flower; twisting, bending, secretly convinced one of us will drop out of the car, so sheer the drop and sharp the turns, we leave the temperate zone for a tropical one of giant ant-hills, lush-leaved vegetation,

sprawling creepers, wild elephants and gabbling *bandar-log*. Now the hills are behind us as we drive across the plateau of the Wynaad, part of the Maharajah's wide domains, whose creepers and lush leaves, wild animals, birds and jungle men, translated into stone, cover with an equally tropical fertility the exterior surface of the famous Hoysalesvara temple in the old capital city, Halebid, once Dorasmudra.

There are few relics here from the ancient world. Kistvaens and cromlechs in the rocky parts of the country, called by local folk "houses of the Mauryans", date from prehistoric times, and the Badagas, hill tribes of the Nilgiris, are considered to be living descendants of these megalithic peoples. The Asokan Edicts prove Mysore to have had Buddhist enlightenment, but no Buddhist monuments exist to-day—there is no Sarnath, Ajanta or Amaravati. But it is more than probable that stupas and monasteries were built and carved with fervour and skill only to be destroyed during the Dark Ages of religious persecution and civil wars between the seventh and eleventh centuries, when—except for a small corner of Bengal—Buddhism mys-

The square pillars of the Gopa-Rayal gateway, Melkote (fifteenth century, see p. 80).



Head of the great Jain figure of Gomata; it is the largest stone statue in the world, and is carved out of a single block (late tenth century).

teriously disappeared from India proper, giving way to Jainism in the West, Vishnuism in the East and Sivaism in the South.

The accomplished technique and virtuosity combined with local idiom displayed in the reliefs at Halebid, Belur and Somnathpur, not to speak of many other less known Hoysala temples, must have had their roots in a long tradition of native craftsmanship which certainly would have been used to the glory of Buddha. Moreover many motifs used in ancient Buddhist art appear in these twelfth- and thirteenth-century reliefs; though probably they were used formally, their real symbolism forgotten. Such a motif is the association of tree and woman in the branching niches over the female dancing figures at Belur; another the lotus creeper, symbol of the ceaseless flow of life, which winds horizontally round the base of all three temples; another the animal and bird friezes at

Halebid—elephant, lion, horse, bull and *hansa*, or sacred goose—in endless procession like the objects of a petrified moving band, carved in the same order, starting with the elephant, as on the rails at Sanchi and the moonstones of Anuradhapura and Pollonarua in Ceylon—the work of craftsmen living more than a thousand years before their medieval followers-on.

Originally the little Vishnuite temple at Aihole, dated 638 A.D.—the oldest structural temple in South India—may have been Buddhist, and the Jain and Vishnuite cave temples at Badami too. These are the most ancient monuments since neolithic days and are important to students of Mysore's architecture and archaeology. But they have little beauty to attract us. Instead we shall find the Middle Ages, from the tenth to the sixteenth centuries, is the period during which Mysore's greatest contributions to Indian art were made. There are three main periods—the semi-classical Jain period of the tenth century represented by colossal Gomata figures, the one at Sravana Belgola—a magnificent *tour de force* echoing Gupta tradition—being the finest; the Brahmanic Hoysala period of the twelfth and thirteenth centuries, of which there are many beautiful and floridly carved temples all over the State, those at Belur, Somnathpur and Halebid being the best examples; and the Vijayanagar period—late fifteenth and early sixteenth centuries, which introduced into Mysore a baroque Renaissance style of flat relief—grotesque, mock-archaic, paying lip-service only to religion, and displaying instead an obsession with the drama and the dance. Although this style crops up in many places, it shows itself to most advantage in the Gopa-Rayal gateway and bathing-tank at Melkote—the former late fifteenth, the latter early sixteenth century. Studying these periods chronologically, we must start by visiting Sravana Belgola.

The village lies between two of the fang-like hills we saw from the Nilgiris, rising melodramatically four or five hundred feet from the level plain. The worship of high places is an integral part of the Jain religion and its temples often crown such hills, those in the South, called *bettus*, being courtyards open to the sky and containing a colossus—not one of the conventional Tirthankars, perfected saints, but a super-human figure—half Raja, half Buddha.

The name Sravana Belgola means, "the White Pond of the Jain Ascetic", and for more than a thousand years pilgrims have journeyed here from all over India to worship at its shrines and make their renunciations—some of the world, others of life itself by the process of slow starvation called *san-yasa*. Inscriptions and records of these ascetics abound on the lower hill, Chandra-giri—"the Hill of Pilgrimages and the Hill of Saints"—which takes its name from Chandragupta, its greatest devotee.

Although authenticated by later inscriptions, it is not clear whether the Chandragupta who came here with his *guru* to meditate, worship and die was the first Emperor, grandfather to Asoka, who travelled from Ujjain in 300 B.C. after the seer Bhadrubahu had foretold a terrible famine, bringing many of his people with him to escape the privations; or Chandragupta II who "in his old age embraced Jainism and, moved to pity at the sight of the famished people of his own land, left the country with a Jain teacher to spend the rest of his life at Sravana Belgola before he died by means of *san-yasa*".

It is possible that the Gomata Raja statue is a sublimation of this legend of a great king becoming a saint, but though Gupta in feeling and technique, it was not constructed until later—in the tenth century A.D. Much earlier are the inscriptions recording other such renunciations; flippantly one might say the Gupta king made Sravana Belgola a fashionable place for asceticism; but that is a cheap remark as only true sincerity and faith could lead a man to starve, freeze and sun-burn himself to death—the sect of the Digambaras, sky-clad, to which Jain ascetics belong, going naked in all weathers.

One inscription dated A.D. 700 and signed "Nantisena, Chief of the Sages" is a small masterpiece. "Fleeting are the treasures of beauty, pleasure, wealth and power—like the rainbow, like the streaks of lightning or the dew. This is the supreme truth.... I do not like existence on this earth." Apparently many others disliked it too, as there are over ninety inscribed records of such renunciations, most of them dated in the seventh and the eighth centuries, the palmy days of Jainism in Mysore and the Deccan.

With so much overcrowding and poverty contrasted with immense wealth and power, it is not surprising that the two religions of the non-possessors—Buddhism and Jainism—should have made such an appeal to the people of India. That by voluntarily giving up the one possession which is truly his—life—a man may gain release from unending recurrence of birth into suffering, is a doctrine which can only appeal strongly to those who find life unendurable or are sickened with the disparity between the good fortune of their own ruling class and the common people's misery. In fact, the doctrine of renunciation of the world and the senses is national rather than sectarian. As one of the Chandra-giri inscriptions says: "The coral-lipped Santisena-muni... on the mount at Velgola having given up food and other things became *lord of the cessation of birth.*"

Another view of the 60-foot statue of Gomata.

This phrase succinctly expresses that apparent contradiction in Indian religious sculpture which singles it out from any other national art in the world. Spirituality and sensuous naturalness, inwardness and delight in outward forms, joy in life and turning away from it—"coral-lipped" as opposed to "giving up food and other things" to become "lord of the cessation of birth". For two thousand years—from Mohenjo-daro to Vijayanagar—this fusion of spirituality and paganism has produced India's most satisfying works of art, with hedonism gradually superseding piety as religion hardened into a rigid and complex iconography.

There is nothing in Indian art of the hieratic Byzantine qualities of Khmer carving, or of the formalized arabesques of Chinese Buddhist art after it had assimilated Gupta influence and become expressive of national feeling. However spiritual and detached from the world the faces of the Buddhas and Boddhisatvas may be, their limbs are always modelled firmly, smoothly, with a graceful sensuous bend and curve of body and an awareness of the vital flux of life. The Gomata Raja we have come to Sravana Belgola to see is a fine example of this fusion of feeling. His eyes have a far-off look, concentrated on spiritual vision; his lips are curved in proud contempt for the world; he stands on his hill conscious of being earth-bound, but drawing strength from it for his final leap into infinity; yet his skin looks soft and smooth, his arms, torso and legs are those of a man in his youthful prime vibrating with life; the granite has become living flesh through the genius of the craftsman who could fully appreciate both the spiritual truth he was expressing in his *vahana*—vehicle—and the flow of sap pulsing through the whole body.

It is extraordinary to find these sensitive artistic qualities on such a huge scale; the figure is the largest stone statue in the world; it stands 60 ft. high and is carved out of a single monolith, probably part of the hill itself—a granite tor—as the work of moving and erecting it at the top would have been a herculean task incompatible to Indian mentality. The Duke of Wellington—not usually addicted to admiring Indian art—was much struck by it as he passed here on his way to Seringapatam, and commented on its size and feat of craftsmanship.

Little archaeological work has been done on it, but its date A.D. 983 is fixed by nearby inscriptions in Kannada, Tamil and Mahratti. Although late classical in technique and feeling—northern rather than southern, and with a tinge of assimilated hellenism—there is a slight stiffening into the medieval without any of the decadence which set in later. I suggest a master craftsman was hired from Central India to direct the work according to the accepted traditions of his school and period, but using local artists to help him. Except for two smaller Gomatas, the conception is unique and has little in common with the usual squat, uninteresting little Tirthankars, being a superhuman figure of great dignity and power—a *chrakravartin*, world ruler. His wide chest and shoulders give him an air of command, he has the curly hair, large ears and lengthened lobes of the Buddha, but not the *urna* and *ushnisha*, the hole in the forehead and the swelling on top of the head. The open lotus (measuring 60 ft.!) is under his feet, *madava* creepers embrace his arms, ant-hills grow up round his legs, yet he is unaware of them both, so deep is he in meditation.

Some of the priests will tell you that he is the son of Purudeva, fourth Tirthankar, sometimes identified with Cupid Incarnate, who gave up his throne to become an ascetic. A legendary statue of him is supposed to have been put up at the time, and this they consider to be a copy of it. But in Jain iconography Gomata is the son of Adinatha, first Tirthankar, and the creepers and ant-hills are his symbols, so most probably he is merely an idealized and inspired version of the usual stodgy yoga figure. But whoever he is, his image is still the object of great veneration to the people—a vehicle of spiritual truth—and every day offerings of garlands and limes and plantains are made to him, and libations of

milk poured over him at certain festivals in the year.

Walking up the six hundred steps towards him we come on a crude drawing of an old woman with a *brinjal*. The story goes that when the day came for the image to be consecrated—3 March 1028—"Chamuda-raya prepared a bath of milk and *ghee*, sacred water, cocoanut milk, plantains, *jagghery*, sugar, almonds, dates, poppy seeds, milk curds, sandalwood, gold and silver flowers, many varieties of precious stones and silver coins", but that when the liquid was poured over the statue it would not fall below the waist, proof that the offering was rejected. Chamuda-raya in despair, seeing an old woman standing by with her humble offering, a *brinjal* of milk, told her to pour it over the Gomata; when lo and behold! it flowed down the statue and bathed the whole hill and the rich people who had come with him for the anointing.

Since then a round basin, the Lake of Labita, has been constructed for overflow libations, and on each side of the colossus stand life-size *chauri* bearers, a yaksha and a yakshi, carved in black stone, reminding us that we are more in ancient than medieval India, the sources Aryan rather than Dravidian.

From the religion of light and air, from the hill-tops and the transcendental image of the worshipping white-robed Jains, we descend to the plain to visit the temples of the Brahmanic sects of Vishnuism and Sivaism, in which are darkness and mystery. Though its mythology is based on the *Vedas*, theologically Brahminism has complicated itself away into a completely different faith, its intricate hair-splitting iconography belonging to the indoor world of abstract argument rather than to the simple verities of life and death, the earth and the heavens, the winds and the sun. It is fitting therefore that its temples should be closed structures with complicated cells and intricate carving, into which little light can penetrate to dispel the mystery of its brooding images.

Carvings in Hoysala Temple
(twelfth to fourteenth centuries).

There are many purely Dravidian temples in Mysore—relics of both Chola and Vijayanagar occupation—with their typical receding storeys and pointed *vimanas*—but none are particularly interesting. Instead it is the Hoysala temples which are unique to Mysore, and their sculpture and architecture are worth going many miles to see although they belong to India's Middle Ages after sculptural decadence had set in. But perhaps decadence is the wrong word to use here to describe such astonishing displays of virtuosity. There is an exuberance, an unsophisticated lip-smacking over natural forms, a full-blooded vigour which cannot be called decadent. Perhaps rococo should be the word. Certainly the little female bracket figures at Belur are rococo, with their Mozartian charm and unaffected grace.

The style of architecture in which the

three temples under consideration, as well as many others in the State, are built, is unknown anywhere else in India and is named after the dynasty which patronized it—Hoysala. Its origins are Chalukyan and the seventh-century temple at Aihole is its immediate predecessor. Really a fusion of northern and southern styles, the horizontal and perpendicular are mixed as in Italian Gothic, thereby developing into a distinctive type of building. Its special features are the beautiful bell-shaped pillars, first roughed out, then turned with a lathe, and the horizontal bands of carved friezes running round and round the outer walls of the temples. The native stone—chloritic schist or soap-stone—helped to condition the work. Soft and easy to chisel but hardening on exposure to air and sun, craftsmen had to work quickly, with

Dravidian figure: Ganga, female divinity of the Ganges.

a flowing line and back-and-forth scroll movement. In this way they covered the whole exterior surface with a lush prolixity of carving expressive of the tropical fertility we met with in the Wynaad jungle.

Occasionally in these temples we come upon a figure or group left rough and unfinished. Probably the donor's money ran out; the sculptor could not pay his assistants

Low relief, showing the hardening of style under the late medieval Vijayanagar school. Cf. Ganga opposite.

and refused to go on, and by the time the money was forthcoming, the stone had hardened into intractability.

A phenomenon hitherto unknown to Indian art appears here at Belur and is peculiar to Hoysala sculpture—the signing of images with their sculptor's names. Malitamma seems to have been the Michelangelo of his day, his name appearing on the finest carvings of almost every important temple. This lack of anonymity suggests court rivalry and intrigue, even medieval favourites. The Hoysala builders and sculptors reflected the spirit of the times—a pagan hedonism which had taken the place of religious mysticism, and a delight in the complexity and vigour of life on this earth to the exclusion of spirituality and other-worldliness.

Perfectly in character then is the obvious obsession with love and sex shown by the "lovely maid" images at Belur, and the many figures "at love" on the walls of the Somnathpur temple. Siva with Parvati on his lap either enthroned or seated on Nandi, his bull, appear again and again at Halebid. And on every single Hoysala temple the *pièce de résistance* in both its sculptor's eye and in public popularity is the Venugopala set-piece—Vishnu's *avatar* as youthful Krishna Orpheus-like charming the animals and birds, the cows, their cowherds and cowherdesses with his flute-playing; the whole pastoral scene reminiscent of a *fête-champêtre* in its mannered charm.

If there was worldliness in the twelfth and thirteenth centuries there was also toleration. All the gods of the Hindu Pantheon, including a Jina and a Buddha, appear on the walls of the Kesava temple, Belur. Kesava—"having fine hair"—is an *avatar* of Vishnu, and an interesting inscription added later by Harihara—"Vishnu-Siva"—of Vijayanagar, points even to Christian influence. "Kesava gives sight to the blind, raises the poor to a royal dignity, causes the lame to be the swiftest of the swift, makes the dumb eloquent and the barren to be a joyful mother of children. May the god Kesava, whom the Saivas worship as Siva, the Vedantins as Brahma, the Bauddhas as Buddha, the Naiyayiksas as Kartha, the Jainas as Artha, the Mimamsakas as Kamma, ever grant your desires."

Carved over each door is the Hoysala crest—a lion or lions attacking a man who strikes out with a sword. Underneath is written "Poy Sala!" Strike Sala! In the temple courtyard a pillar commemorates a grisly act of feudal devotion: "When King Ballala II went to heaven his wife and cousins and one thousand warriors accompanied him by the rite of self-beheading.

This they did by means of a bent sapling, which when released, sprang up and carried the victim's head with it."

The temple at Somnathpur, a walled town twenty-four miles from Mysore City, is later than the Kesava temple at Belur and the Hoysalesvara temple at Halebid. Although not a royal temple, having been built and endowed in 1268 by the governor of the province, Somanatha, it is Hoysala in style, and architecturally, for shape—a sixteen-pointed star—and proportions it is more beautiful than the other two. Its platform, 3 ft. high, is supported by elephants, *nagas* and *yakshas*, and the usual band of elephants processes round its base. These elephants are caparisoned for war, and though a little cramped, are delightfully playful; tossing branches about, tweaking each other's tails, mischievously trampling their riders underfoot. Above them, the horseman frieze is worth particular notice. The horses are natural, well-modelled creatures, ridden sometimes by soldiers in shorts and long boots, sometimes by a prince under his state umbrella followed by dwarfs and attendants. In between the horses are camels which also are well modelled, a proof that these creatures were used by the Hoysala kings in war and were not strange to the artists who depicted them.

For about two centuries there was little Hindu building in Mysore, which groaned under Mohammedan rule, and when it became part of the Hindu Vijayanagar Empire in the fifteenth century the Hoysala style was dead.

Although the policy of Vijayanagar's Emperors was to conserve the old buildings and culture of the South, they could only give grants for repairing and restoring Hoysala temples; they could not resuscitate a tradition which had perished with the old kings. Instead they built new temples, gateways and bathing-tanks for themselves, bringing their craftsmen with them and waking in Mysore a third period of sculptural energy which we may call baroque. To see it at its best we must visit Melkote, the holy hill-town of the Vishnuvites, where the Gopa-Rayal gateway and bathing-tank are carved with reliefs as fine as anything elsewhere of the Vijayanagar period.

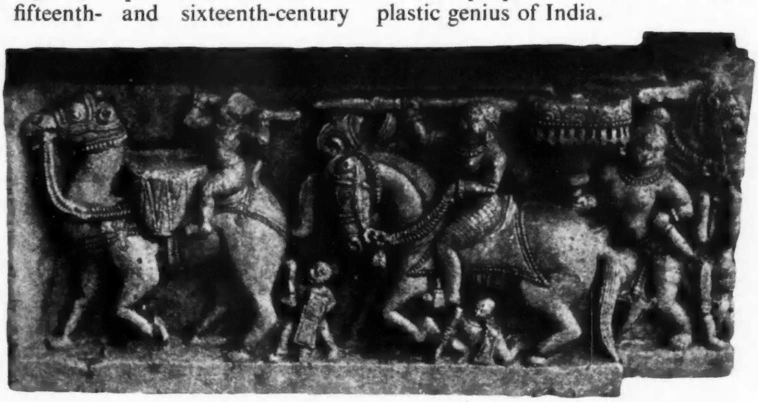
There is nothing in these low reliefs of the tough roundness and vigour of the Hoysala sculptors, and nothing could be further from the classical and spiritual Gomata statue than these angular flat carvings in their little frames, these grotesque dwarf musicians and fluid dancing figures on the sides of the tank. The sixteenth century was evidently an age of artistic as well as religious tolerance as the two Gangas, female divinities of the Ganges, standing on their *makaras*, mythical rhinoceroses, and holding up thick ropes of lotus creeper, are pure Dravidian in their slenderness and graceful relaxation in the *tribhanga* bend. Yet how can they be in company with the Babylonian-looking female holding a garland—her body cramped and distorted to fit into the flat planes of her creator's self-imposed geometrical rules? with her squat body, flat feet, long pointed nose and pseudo-archaic appearance? And with the delightfully natural mother and child, whose sculptor tried to follow the same set rules, but fortunately was carried away by his theme?

Relief of mother and child on the Gopa-Rayal gateway, Melkote (late fifteenth century).

The Babylonian-looking insets are pure Vijayanagar in style, partly influenced by its Telugu rulers and reminiscent of Telugu village mother goddesses, but more strongly by Gujerati paintings and puppet-play types, often archaic and always depicted with angular noses, distorted bodies and large feet. The flatness of painting and of shadow-play figures was copied by sculptors of the period, many of their efforts being lively line drawings rather than moulded reliefs. The fabulously wealthy Hindu court at Vijayanagar patronized the frivolities of drama and dance, a foreign traveller describing the court as being "full of courtesans, dancers, jugglers and performing elephants", and people were attracted to these forms of art rather than to religion which had hardened into lifeless theology. This interest re-vitalized sculpture and painting, giving craftsmen a new direction. Figures of the period—their postures, gestures, hands, drapery and ornaments—are all influenced by the dance. The "girl with garland" shows this influence clearly. Her hands and fingers are in studied dance positions. The bathing-tank figures are all musicians or dancers and their sculptors have succeeded brilliantly in drawing out of the stone a flowing movement and plastic urgency, though the heavy beaded ornamentation of the dwarf musicians partly impede this movement.

Dwarf musician (early sixteenth century).

This fifteenth- and sixteenth-century renaissance and incursion into the baroque was India's last flare up of sculptural inspiration. Long before, the spread of Islam had destroyed the spark and much of the actual creation in Northern, Central and Eastern India. Hindu Vijayanagar kept its tide at bay in the South and West till the end of the sixteenth century, but after its fall Hindu arts flickered and died down. And on top of Islam came the alien ethos of Europe to blow it out altogether. Will it flame up again? Surely the inspiration of a growing national consciousness and common purpose will rouse the remarkable plastic genius of India.



Thirteenth-century Hoysala frieze.

Einstein on the Evolution of Physics

Below we print two reviews of the recent book by Professor Albert Einstein and Leopold Infeld (*The Evolution of Physics*, Cambridge University Press, 8*s*. 6*d*.).

An explanation of Science for the non-scientific public ought if possible to be judged in two ways—first by a scientific specialist, and next by an intelligent reader of the class to whom it is addressed. Dr Sutherland, the author of the first review, is a fellow of Pembroke College, Cambridge, and carries out mathematico-physical researches in the structure of molecules; Mr Howard has written both technical and general accounts on various subjects in modern European history.

The Specialist writes:

AS one might expect from the names of the authors (if not from the dust cover) this book represents a serious attempt to convey the evolution of physical ideas from pre-Galilean times to the present day. It may be read with profit by professional as well as non-professional physicists, although it is primarily addressed to the latter.

The book is divided into four main sections corresponding to the rise of the mechanical view, the decline of the mechanical view, the introduction of the "field" concept and of relativity, and finally the rise of the quantum theory. The logical development of the first three sections is very beautifully carried through using purely physical concepts. The non-mathematical treatment of Maxwell's field theory and of special and general relativity is a brilliant example of scientific exposition. Only very occasionally do the authors lapse into the conventional language of relativity theory. Thus (on p. 197) they state that "Maxwell's equations are not invariant with respect to the classical transformation". Even though the essential of the invariance of physical laws in different co-ordinate systems has previously been explained, such phraseology really refers to the mathematical expression of this idea. Again, on p. 303 the mathematical idea of a "function" is introduced without much explanation. One wonders in fact whether the exclusion of mathematics has not been too rigid. A little more might have been added with profit, for much of the beauty of the relativity theory is surely in the simplicity which it brings to the mathematical formulation of physical laws. Yet to give just sufficient mathematics with its concomitant explanation might have made the book too unwieldy and have given the erroneous impression to potential readers that relativity is only comprehensible by a mathematician.

The treatment of the quantum theory in the last section is not so successful, largely because it is too condensed. The first three-quarters of the book probably contain less factual knowledge than the last quarter. The discussion of the ideas of

the quantum theory is consequently very brief. The authors may have felt that since no satisfactory quantum theory of the "field" has yet been achieved, it was better simply to state the difficult facts which necessitated the introduction of the quantum hypothesis with some indication of present explanations. A treatment of the ideas of the quantum theory with the same thoroughness as that exhibited in the treatment of relativity requires much more space than has been allowed in the present book.

Although the title might more properly have been "the evolution of theoretical physics", the relation of theory to experiment is emphasized throughout with much illustrative detail. The brute facts which contradict old theories and necessitate new ones, the testing of the new theories by new experiments, the discovery of still more troublesome facts requiring still more comprehensive theories, in other words the sense of the continual struggle to widen and simultaneously to unify our knowledge of the physical world, is extremely well conveyed.

The book is written in admirable English and is pleasantly illustrated with many line drawings and a few well-chosen plates. We notice that it represents the first of a new series to be published from Cambridge on Modern Science. Prof. Einstein and Dr Infeld have set a high standard for future authors.

G. B. B. M. SUTHERLAND

The General Reader writes:

I AM one of those non-scientific scholars who have long wanted a clear statement of the past advance and present state of scientific knowledge. I had almost despaired of getting it. I have read books and then heard that they were out of date; I have been told mysteriously by scientific friends that present scientific concepts are expressed in terms which the layman would not understand. This book has given me just what I wanted, as far as physics is concerned. The authors promised me at the beginning that it would rather resemble a detective story: and at the end I have to admit that I have read it with naïve and enthralled interest. I have had, it is true, to use a degree of concentration at times which I daren't believe everyone will use; but so, alas, I have often had to do with a good many detective stories.

I came to this book with little Heat and less Light, not to speak of no Mechanics and no Electricity. I find that it has answered clearly many of my questions. I have put it aside for a day, after reading it through once; and I find that I have a number of new pictures staying in my mind which I did not possess and wanted to have.

In the first place, I have long wanted a picture of the main development of physical knowledge. Now I understand the development of the mechanical view from the discoveries of Galileo and Newton, and the subsequent decline of that view after the difficulty over the movement of a magnetic needle into the wrong plane. (Incidentally, I am sure that many non-scientists still assume that physicists have a purely mechanical view; and in many respects this outside attitude to

science is a harmful one. It means, for instance, that those who have to deal with human beings and their relations feel that their studies cannot be scientific because they are not mechanical.) I understand the development through the concepts of the field and relativity to the quantum method of approach; and the writers have convinced me that it is inevitable and right.

Secondly, I wanted to know how the physicist pictured the world. Now I have a pretty good idea. I understand what Relativity means—and I never believed that I should. I could almost talk Quanta. Incidentally, I am threatened by a powerful temptation to spend a lot of time studying modern physics in more detail. I expect I shall compromise by merely asking my scientific friends innumerable questions.

I found one effect which the authors did not, perhaps, foresee. When they discussed a theory, or gave an explanation, I could follow them without great difficulty (though not, as I said before, without concentration). But when they referred to some of their experiments, I felt a shiver of unbelief: they seemed so impossible and unfamiliar. Perhaps it would have helped if they had given a very detailed account of just *one* of those difficult modern experiments! I should then have found it easier to take the rest for granted. Or perhaps I ought to watch someone doing one of them.

I want now to read a similar book on Chemistry, and another on Biology.

H. E. HOWARD

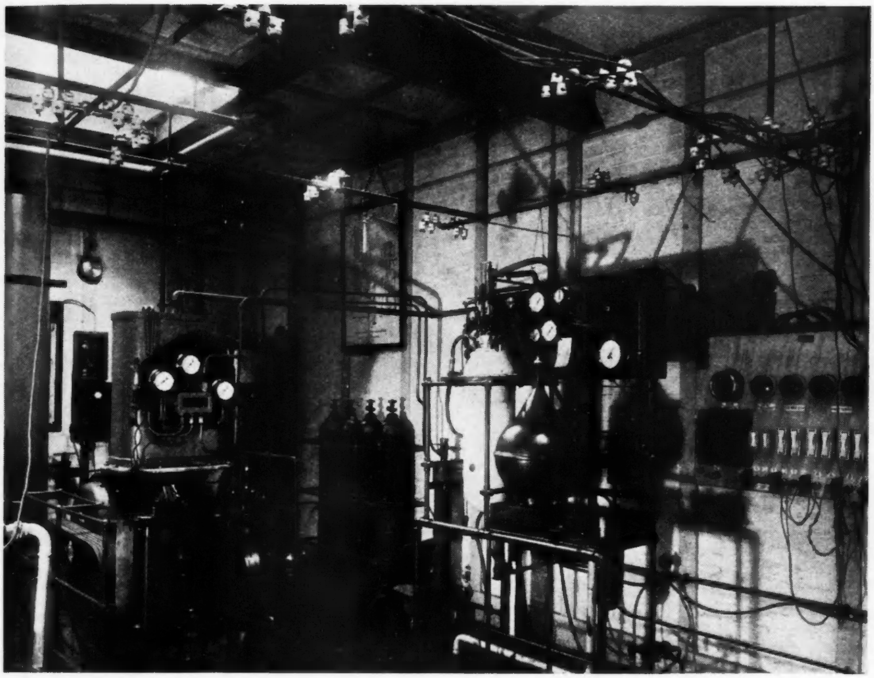
To the Editor

Sir, Congratulations on the first copy of the new *Discovery*. But you will give us historians and synthesizers a turn now and then, won't you? I feel myself that the bringing together of the new knowledge which is pouring into the world is just as important as keeping us up to the latest discovery.

The review of my book *The New Vision of Man* by H. E. H. is so friendly and interesting that I am sure he will welcome a clear disclaimer from me of one "assumption" which, oddly enough, he seems to attribute to me on a matter where I thought I was particularly explicit. Of course I do not assume that all the stages of human development have been in the right direction: e.g. though holding that the Roman Empire was on the whole for the good of mankind, I pointed out how certain features in its growth, such as the Third Punic War, were hideous mistakes. So, of course, we might judge of many other particular steps in the human progress which has yet, on the whole, led us to a state of civilization superior in its essentials to what has gone before. We are at the moment at grips with one or two other grave evils or errors which I believe—and I think H. E. H. will agree with me—will yield to the general upward pressure of human reason. There is faith in this, and much speculation, but the past, broadly viewed, is on our side.

WELWYN GARDEN CITY, HERTS. F. S. MARVIN

Helium Liquefying Apparatus in the Mond Laboratory at Cambridge.



459·8° F. Below Zero

By L. Infeld

(*In* The Evolution of Physics, *Einstein and Infeld showed how the "difficult" ideas of physics could be explained both clearly and charmingly. In this article, Dr Infeld leads us through another difficult idea with the same ease.*)

"TAKE some more tea", the March Hare said to Alice very earnestly.

"I've had nothing yet," Alice replied in an offended tone, "so I can't take more."

"You mean you can't take *less*", said the Hatter: "It's very easy to take *more* than nothing."

The Mad Hatter's reasoning seems sound enough, whether it applies to tea or any other substance. Does it also make sense when extended even further, for example, to heat and temperature? If a body is supplied with heat its temperature rises. Starting with any temperature one can perfectly well imagine a higher temperature, at which the body contains more heat. Is it also possible to imagine a temperature lower than any initial one? Or is there a degree of cold beyond which it is impossible to take still more heat from the body, just as Alice couldn't have less tea than none? The answer to this question was already known in the nineteenth century: There does exist a lowest temperature,

known as *absolute zero*. By the ordinary Fahrenheit scale, such as is used to measure the temperature of a sick man or a room, this lowest temperature is about 459·8° below zero.

The Records of Coldness

Once such a concept was established, scientists realized the importance of investigating the attractive field of low temperatures. Experimental physicists began a long race to a new goal: the temperature of absolute zero. Records were made and broken. Lower and lower temperatures were reached. A new region of investigation was conquered, but by no means fully exhausted. Scattered throughout the civilized world to-day are many low-temperature laboratories in which scientists are still working toward the same goal.

How far is there to go?

Before discussing the results achieved during the last few years we may remark on how little or how much of the race remains before us. It is difficult to express the result in numbers; given to-day, it may very well be out of date in a few weeks. I shall only say, then, that scientists have reached temperatures differing from that of absolute zero by something like a hundredth of a degree. It would perhaps seem that the goal is almost reached. A hundredth of a degree is not very much. Might we not be a little less pedantic, neglect this minute difference, and proclaim triumphantly that the problem is solved? By no means. Scientists realize that the problem is far from completion. Each small step further is more difficult than the previous one. And perhaps more important, since each step may reveal aspects of the structure of matter in a region of great interest from the point of view of modern physics. An example will show the difficulties connected with the investigation. Let us imagine that we are trying to approach a great wall in some fantastic world. Strange things happen: as we come nearer the wall an uncanny metamorphosis takes place. All our dimensions, and consequently the length of our steps, become smaller and smaller. Our dimensions and our steps diminish at such a rate that they approach zero as our distance from the wall approaches zero. In this fantastic world we are bound to suffer disappointment. At first the wall seemed only a finite distance away, but we begin to understand that we can never reach it because we can approach only by ever-diminishing steps. Something like this happens in the march of science toward absolute zero. To go a thousandth of a degree lower is an incomparably greater task now than it was to make the same step at a temperature only a few degrees higher.

The Principle behind the Experiments

But what is the principle of the experiments for attaining low temperatures?

We have a gas enclosed in a vessel. According to the picture given by the kinetic theory of gases, the molecules are in constant motion. They collide with each other and with the walls of the vessel, changing the direction of their motion at every collision. In this tremendous and varied crowd of molecules some have large velocities and some small, but there exists an *average* speed, just as in a crowd of people of a variety of ages there exists an *average* age. This average speed of the molecules is, so to speak, a measure of the temperature of the gas. That is, it corresponds microphysically to the quantity determined macrophysically by a thermometer. A rise in temperature means microphysically an increased molecular motion; we diminish the temperature by causing the particles to move less rapidly. If we could make all motion cease, leaving the molecules at complete rest, absolute zero of temperature would be achieved. The problem of reaching the lowest temperatures is, therefore, just that of finding

ways and means of reducing the motion of the molecules. Several ways of doing this are known.

One of the earliest methods was a purely mechanical one. A billiard ball, after being bounced off a stationary wall, has the same speed as before, although in a different direction. If, however, the wall recedes during the advance of the ball, its speed will be diminished by such a bounce. This is exactly what happens to the molecules of a gas in a vessel closed by a moving piston. As the piston is rapidly moved outwards, the molecules striking it lose part of their velocity. The average velocity of the molecules, and thus the temperature of the gas, will be lowered. But this mechanical method of lowering temperatures is rather crude, and it is impossible to reach the neighbourhood of absolute zero in this way.

Down to 1·3° absolute

Everyone knows that coffee does not boil at the same temperature at the summit of Mont Blanc as it does at home, due to the difference in atmospheric pressure. At a pressure lower than normal, water boils at a temperature lower than 212° F., the normal boiling point. Thus someone who would like to cool his tea could do it in a complicated way by putting it under a flask attached to a vacuum pump and forcing it to boil at a lower temperature. If, say, one has a flask of liquid air, he may diminish the pressure about it, decreasing the temperature until it is low enough to liquefy hydrogen. Repeating the same procedure, diminishing the pressure on liquid hydrogen, he may then liquefy helium. This is already within 9° F. of the absolute zero. He may use the same idea once more, diminishing the pressure on liquid helium and, by using the best vacuum pumps, he may lower the temperature a little more than 7° further. This brings us as near as 1·3° F. to our ultimate goal. It seems the best one can do with these methods, however, and a new idea is needed if we wish to go further.

A New Idea

We have seen that by the application of simple methods developed in the nineteenth century, the scientist is able to reach a temperature differing from the absolute zero by only a little more than one degree. A most ingenious idea of Debye opened the way to still lower temperatures. The idea was carried out some few years ago by Haas in the famous low-temperature laboratory at Leyden, Holland, and by Giauque in America. It is connected with a very simple theoretical concept and is a striking example of successful collaboration between theory and experiment.

What is this theoretical idea?

Suppose that a crystal of some substance is placed in a bath of liquid helium, and the temperature lowered as far as possible by the old method. There is very little motion of the molecules at such a temperature, in either liquid or crystal. Now, suppose it were possible to excite the molecules of the crystal to more rapid motion. We know that the excitation of motion is necessarily connected with the absorption of heat, and its slowing down with a decrease of temperature. If, therefore, the crystal lying in its bath of liquid helium is suddenly excited to greater internal motion, it must have taken the necessarily accompanying heat from its surroundings, that is, from the helium. But this means that the helium has a lower temperature than before.

Freedom and Disorder

Perhaps we shall find another comparison helpful. If we observe the courtyard of a military barracks we may see crowds of soldiers walking about in disorder, going in different directions, each doing as he likes. Suddenly there is a command to form ranks. In a very short time the soldiers are standing in absolute order, and the freedom of their movements, before so great, is now very restricted. Only after the order for dismissal can they move freely and independently once more.

What are known as paramagnetic substances behave under the action of a magnetic field much as a well-disciplined army at attention. Platinum and aluminium, for example, have their molecules ordered by a magnetic field, each molecule behaving as a small magnet and aligning itself along the direction of the magnetic field, much like a compass needle. The degree of order induced depends on the strength of the magnetic field applied, just as the order of the soldiers depends on the strictness of the discipline to which they are subjected. Disorder reigns again if the magnetic field is removed, and the freedom of motion for the individual molecules is distinctly increased. Suppose the crystal immersed in liquid helium is a paramagnetic one. Let order and regularity be forced on the molecules by the presence of a magnetic field, and lower the temperature as far as possible by diminishing the pressure on the helium.

0·001° absolute

Now comes the most important point in the process: remove the magnetic field. The particles of the crystal are no longer obliged to remain in their previous positions and are free to move about. But every increase in freedom of motion *must* be accompanied by the absorption of heat. This heat *must* be taken from the substance immediately surrounding the crystal, that is, from the helium, and a decrease in heat content means a decrease of temperature. The change from order to disorder in the crystal depends on the amount of order present, which in turn depends on the strength of the magnetic field. Thus the change in temperature of the helium is more distinct for great fields than small ones. On this principle, using very strong fields, the temperature may be decreased to within only a thousandth of a degree of the absolute zero of temperature.

But a doubt arises here. How does the scientist know what temperature he has reached? Mercury freezes at −40° F., so that a mercury thermometer is useless for measuring a temperature lower than that. Gas thermometers have a wider range, but certainly not extending so near the absolute zero as we need. What sense is there in talking of temperatures in a range where thermometers are useless? How is it possible to speak about numbers of degrees at such low temperatures?

Measuring the Lowest Temperatures

The underlying principle of the mercury thermometer is that a thread of mercury changes its length with changes in temperature. We determine the changes in temperature by the changes of physical properties with which they are connected. If there exist properties which change in some predictable way with such low temperatures, then our problem is solved. It is true that the magnetic properties of a body responsible for the conquering of the low-temperature range do change with temperature, and that just these changes make it possible to determine those temperatures near to absolute zero. The problem is connected with many theoretical and experimental difficulties, however, and will still demand years of difficult and tedious labour to develop it further.

Why are such investigations so important from both the experimental point of view and the theoretical? Let us return to our comparison: in approaching the temperature of absolute zero we are like the wanderer whose dimensions decrease as he approaches the wall which is his goal. At the same time that his steps become smaller and smaller, other phenomena change their appearance and disclose their microphysical, that is, their *quantum* character. At low temperatures the crude macroscopic laws formulated to describe the behaviour of physical phenomena at ordinary temperatures are no longer valid. In the realm of low temperatures the quantum theory must be applied. The quantum theory succeeds not only in explaining many of the features peculiar to this new

realm of knowledge, but also, in many cases, in predicting hitherto unknown phenomena.

The Strange Effects of the Lowest Temperatures

Let us mention one example. Perhaps we remember from school the definition of the specific heat of a substance as that quantity of heat necessary to raise the temperature of unit mass of the substance through one degree. Increasing the temperature of a body from 0 to 1° F. requires a slightly different quantity of heat from that necessary to change the same body from 200 to 201° F. In other words, specific heat changes with temperature, and not in the same way for different substances. The changes differ for water, air, copper and so forth. What happens to the specific heat at low temperatures? The answer to this question was unexpected. There the specific heats of all bodies behave in the same way, approaching zero as the temperature approaches zero. The amounts of heat which must be taken from a body in order to decrease its temperature by a certain amount get smaller and smaller just as do the steps of our fantastic wanderer. It is just this vanishing of the specific heat with the temperature which the quantum theory explains so clearly.

Not all low-temperature phenomena are so fully understood, however. We may mention one experimental fact for which no clear and convincing explanation has so far been given. It is a familiar fact that heat is generated in a wire carrying an electric current because of the electrical resistance of the wire. A current set up in a wire quickly dies down, and all its energy is transformed into heat if not excited by a source of electricity. If, however, a current is established in a circuit of lead wire kept at the temperature of liquid helium, a strange phenomenon appears. The resistance vanishes completely. No heat is generated, and a current once excited can flow for days without showing any change. This phenomenon is called *superconductivity*, and is a property shown by many conductors. All the energy waste inevitable to the transmission of electricity could be avoided if only the well-established facts of superconductivity could be put into practical use! If we could only pass the transmission lines through an atmosphere of liquid helium! This is a naïve thought. It is quite evident that because of the high price and difficulty of preserving liquid helium, this idea must long remain in the realm of the imagination. It often takes a long time for physical ideas to be applied to technique. But the importance of the ideas must never be judged by the extent of their present influence on our everyday lives.

The Use of Ship Models

By D. H. C. Birt

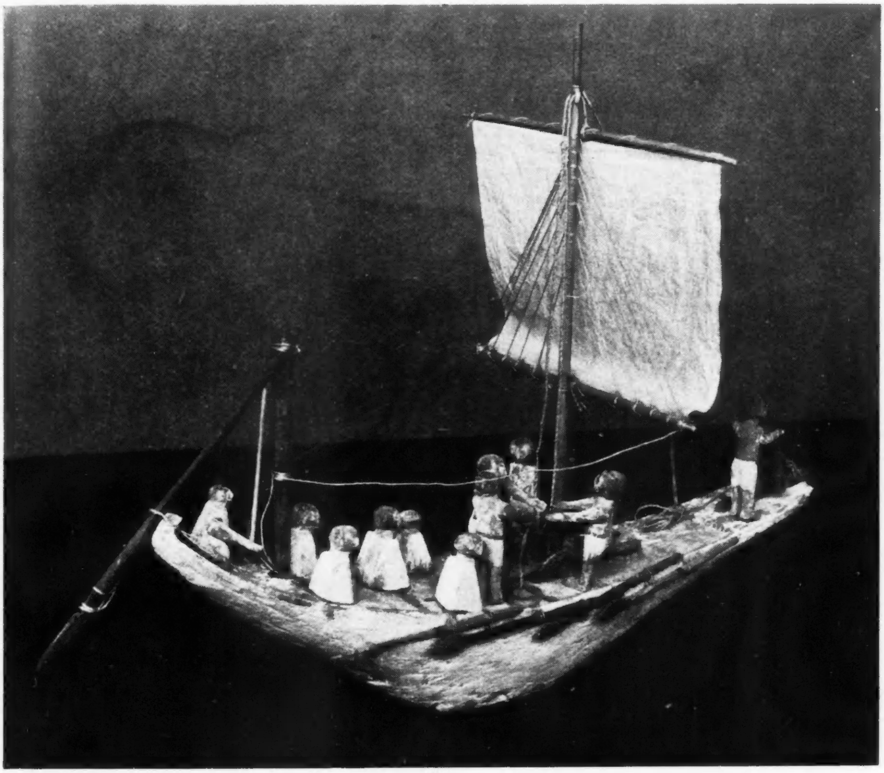
The making of ship models is among the oldest handicrafts known to man. The reason for this is not far to seek, for in the lives of primitive people boats were a predominating feature. The making of models of these ships was a form of self-expression that would come to these ancients as naturally as carving bas-relief, or drawing weird pictures on rocks. The oldest ship model to-day in existence has an age of about 4000 years, but long before that time models were certainly constructed. Indeed, as soon as man left behind the primitive stage when he lived entirely by hunting, and found time to practise something in the nature of Art, then probably the first ship models were fashioned.

There is a contemporary model in the Science Museum at South Kensington of an Egyptian boat *circa* 2000 B.C., which was found at Beni-Hasan in a tomb of the XIIth Dynasty. The fact that it was found in a tomb is common to many early ship models. Until after the period of the Reformation in Europe, they were all constructed with a religious motive, and were frequently buried with a chieftain or king, for all early peoples regarded ships with a reverence that seems strange to-day. Ships were often the means of their livelihood or the cause of their wealth, while long sea voyages were fraught with great dangers. Thus ship models were sometimes buried, along with other valued possessions, in the tombs of the departed.

Sailors home from long and dangerous voyages made models to hang in churches as thank offerings to their patron saints; this practice was particularly prevalent in Roman Catholic countries until the Middle Ages. These models, designed to be looked at from below, were frequently poor pieces of work, but to the historians of to-day they are invaluable. During the Reformation all models were banished from the churches, and usually ruthlessly destroyed. Thus were lost some of the most priceless records of medieval shipping.

About the end of the sixteenth century, a new era of ship modelling began. It was a growing custom in this country towards the end of Elizabeth's reign for shipwrights to make models of their designs to guide the builder, and also to aid the imagination of a prospective client. This practice spread to the Navy, and the first builder of official models of whom there is record is one Phineas Pett, a member of a family that for many years had great influence in English shipbuilding. His son, Peter Pett, carried on his father's traditions, and a contemporary description of a visit to his workshop is found in *Peter Mundy's Travels*. There, he says, "wee sawe the modell on molde of the said shipp, (H.M.S. Sovereign) which was shewne unto his Majestie before hee began her. The said Modell was of exquisite and admirable workmanshipp, curiouslye painted and guilte with azur and gold, soe contrived that everye timber in her might be seene, left open and unplancked for that purpose, very neat and delightsome. There were also Modells of divers other shipps lately built, but nothing comparable to the former." This is probably the earliest description of a collection of ship models.

In 1654 it was expressly ordered by the Admiralty that all builders who contracted to build a ship for the state must first make a model of her to show their Lordships. This was again emphasized in 1716. Some of these official models were built by the Navy Board, and these are to-day the most highly valued; while others were made by private firms under contract from the Navy

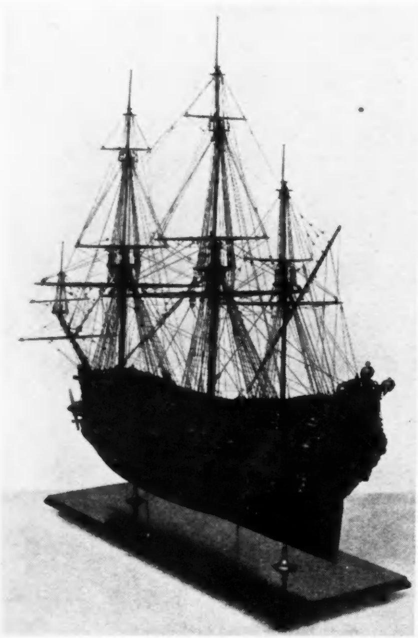


A model of an Egyptian ship, *circa* 2000 B.C., found in a tomb at Beni-Hasan. (*Science Museum, South Kensington.*)

Board. The distinctive feature of these models was the system of "open frames" employed, this being particularly mentioned in Peter Mundy's description. Usually the lower part of the hull was left unplanked, while the topsides were shown as in the real ship; but in some no planking was shown whatever. In both these systems the model was framed exactly as the prototype, without any simplification. The omission of all or part of the planking rendered this intricate work visible. Frequently only one side of the deck was planked up, thus enabling the deck beams and other interior work to be clearly seen. In later years the under-water part of the model was carved from the solid, the topsides being built on to this. Other models showing only part of the hull, but that to a large scale, were common and were used with the particular purpose of aiding the builders.

Few official drafts have survived of ships between 1660 and 1720, and contemporary engravings are unreliable. Hence most of our present-day information of the shipping of this period is based on the large number of surviving models, and students spend much time tracing the name and date of unidentified ones. This is frequently a very difficult job. A model might be made of a ship as she was originally designed, but while on the stocks considerable alterations

might be made. This renders the fixing of a name, or even an approximate date, to a model a formidable task, and it sometimes takes years of research through official documents to come to a decision. Few of these models have come through with their original rig intact, and they have often been rerigged at a later period in the style then prevailing. The result is that they bristle with anachronisms, and are useless



Contemporary model of the *St Michael* (1669). (*Formerly in the Science Museum, South Kensington.*)

for purposes of identification. For some reason, after 1720, the practice of building models became temporarily less common, but as far as the historian is concerned this is compensated for by the large increase in the number of official drafts still in existence.

During the Napoleonic wars many of the French prisoners-of-war then in England made ship models to while away the long hours of captivity, and to make a little

Model of a French 44-gun Frigate, built of wood by a prisoner of war. (*Formerly in the Science Museum, South Kensington.*)

money to purchase luxuries. These were generally carved from the mutton bones left from the prisoners' meals, and were, in some cases, remarkably intricate pieces of work. The more reliable of them, from an historical point of view, had the hull carved from wood, sometimes having tinfoil on their under-water portion to represent copper sheathing. In the smaller examples the rigging was beautifully executed with human hair. Few of these have come through to-day in their original state, and in all too many cases they have been spoilt by ignorant restoration. The few perfect examples fetch high prices, as much as a thousand pounds having been paid for a perfect example.

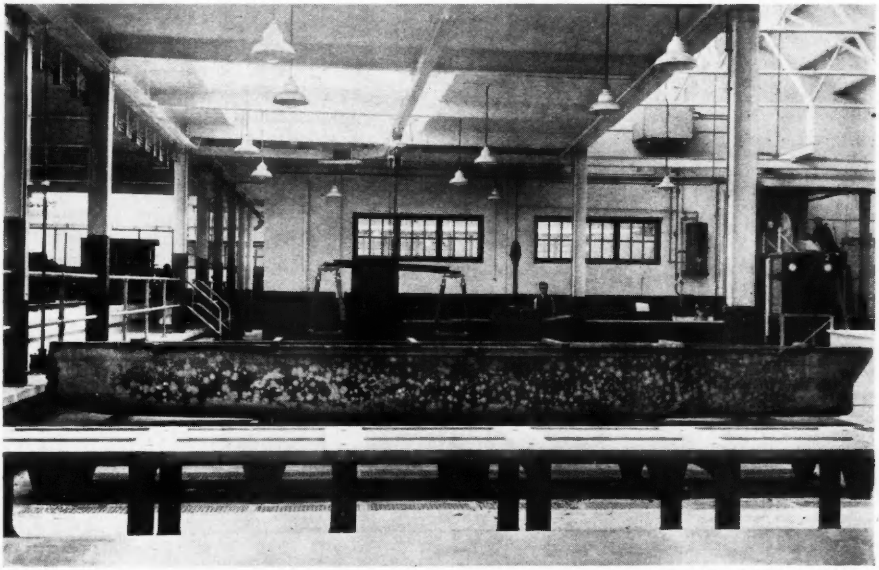
But notwithstanding the value of these prisoner-of-war models as curios, historically their value is questionable. Though usually representing French types of ships, they bore English names, to attract buyers in this country. In fact they suffer from the fault common to all sailor-made models,

of being a little of everything, without giving certain data about anything.

While the historical value of ship models is permanent, it seemed towards the end of last century that their practical and commercial value was at an end. We have seen how they were used extensively by the Navy Board and shipbuilders for many years. Until comparatively recent times, too, the method of designing yachts was simply to carve a model to the desired shape, a good eye backed by years of experience being here necessary, and next to saw it up, so obtaining the sections, which could then be laid out full size. Though many fine vessels were created in this manner, it was too "hit or miss" a method for modern times, and it appeared that the drawing board and pencil were going permanently to supersede the use of the model. This, however, was destined not to be, for to-day the model has once more become the indispensable tool of the naval architect.

The new value attached to it lies in the ability of a towed or self-propelled model to foretell the behaviour of the real ship. For many years experiments were conducted along these lines, the pioneer being the famous William Froude. This work eventually culminated in the construction of a special testing tank at the National Physics Laboratory, Teddington, in 1911, followed in 1932 by another at the same place. Besides these, two well-known shipbuilding firms have also their own tanks. To-day models of all types of vessels, ranging from cargo lighters and barges to Atlantic liners, are thus tested, and it is reckoned that the data so obtained has saved the shipping industry millions of pounds.

From the designs of the proposed vessel, a wood model is carved. By means of templates a hollow is next formed in a bed of clay, of the same shape as the model, but slightly larger. The wooden model is then covered with canvas and inserted in

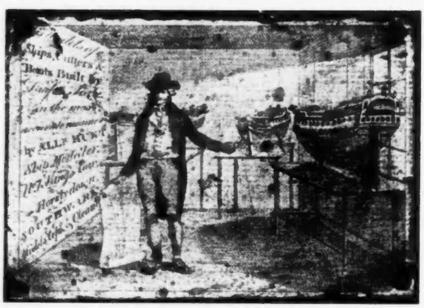


(By courtesy of H.M. Stationery Office.)

A partially made wax model for use in the testing tanks of the National Physics Laboratory, Teddington.

the hollow, a small gap being left between it and the clay, into which hot paraffin-wax is poured. When cold, the resulting rough cast may be taken out of the mould, and the canvas-covered frame removed. This cast is next placed on a moving cradle in the cutting machine, to which has been attached a scale drawing of the hull "lines". By moving a pointer over these "lines" grooves are cut in the wax exactly conforming to the lines of the ship. When taken off the machine, the process of shaping or "dressing" is done, skilled workers carving away the surplus wax between the grooves, until the model presents a smooth exterior. Finally, the model is ballasted to float on her designed waterline.

A number of things can be accurately determined with a model, which could only be guessed at otherwise. It is towed up and down the tank by means of overhead machinery, a suitable time being allowed between each run for the water to subside. Dials record directly, with due allowance for the difference in scale, the resistance that would be encountered by the real ship, from which the necessary power to drive it may be calculated. Any alteration in hull form that suggests itself may easily be executed in the model, whence it can be transferred to the ship proper. Self-propelled models with electric recording gear attached to their propelling machinery are used for determining such things as propeller thrust and torque. Propellers are, in fact, the most important factor in the behaviour of a modern ship. Their ideal form, however, for different ships can be determined only by trial and error. This may be done either at tremendous expense on the ship herself, or by the comparatively inexpensive method of experimenting with models.



Professional model-maker's advertisement of eighteenth century. (*Science Museum, South Kensington.*)

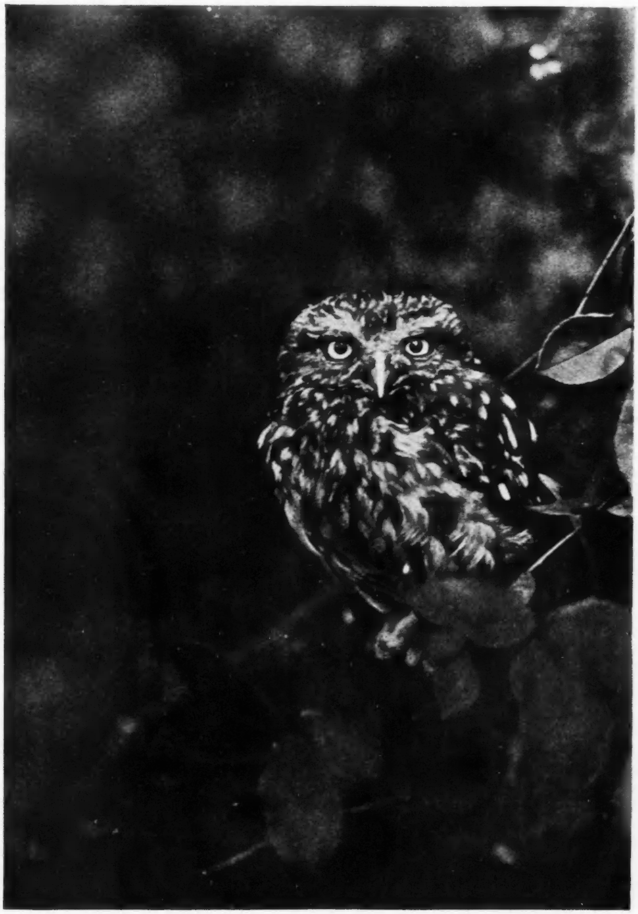
In recent years much research has been undertaken on hull and propeller design in this manner. During the post-war slump, shipowners found it necessary either to alter their existing ships or to build new ones, if they were to have any chance of overcoming foreign competition. Tests with models of ships laid up as unpaying propositions suggested improvements which made them once more paying units of their fleet. One example, taken from thousands, may be cited to illustrate the financial value of these model tests. From the results obtained with a model of a certain ship, it was found that 9650 horse-power would be necessary to drive the ship at 19 knots. A new model was built embodying alterations to reduce resistance. It was then found that 8700 horse-power only would be required to drive the ship at the same speed. The saving thus caused in the coal bill was estimated at over £3000 per annum.

Possibly the most spectacular, though not the most useful, example of tank testing was in the experiments carried out with various models before the final choice of hull design for America's recent Cup defender *Ranger*. The problem of testing models of sailing vessels was very different from that of testing models of steamships, and satisfactory results had never been obtained in England. The problem was under consideration for many years in America, chiefly by Prof. Davidson and the well-known racing yacht designer, Olin Stephens. The finest tribute to their success lies in the handsome manner in which *Ranger* defeated *Endeavour*, herself a very fast vessel. The American designers admit that but for the positive results obtained from the tank experiments they would never have dared to give *Ranger* the hull form that was eventually chosen.

The Little Owl Needs Watching

By E. W. HENDY

IN *Discovery* for October 1935 I discussed the character of the Little Owl (*Athene noctua vidalii*) in the light of two contradictory reports on its food habits published by the British Field Sports Society and Miss Hibbert-Ware; the evidence then available left me with an open mind.



The present *Report**, which is a most careful and accurate compilation, practically exonerates the Little Owl from blame. The Scientific Advisory Committee appointed by the British Trust for Ornithology to investigate, with the help of Miss Hibbert-Ware, states that only negligible destruction of game and poultry or wild birds is proved, and that the Little Owl feeds, except in abnormal circumstances, almost entirely on such insects, other invertebrates and small mammals as can readily be picked up on the ground during its hours of feeding—largely from dusk to early morning.

Miss Hibbert-Ware's *Report* is exhaustive; shortly, her conclusions are that the Little Owl is chiefly crepuscular and nocturnal, but sometimes hunts by day; it is primarily a ground feeder, chiefly on insects and rodents: very little carrion is used. The so-called "larders" are not used for storage and are more accurately described as "refuse dumps".

* *Report of the Little Owl Food Inquiry*, 1936–37, by Alice Hibbert-Ware, M.B.O.U. H. and F. Witherby, 3*s.* 6*d.*

There is no evidence that prey is killed for storage in order to produce carrion beetles for future consumption. Birds are, with insects and rodents, an important food constituent during the nesting season; those most commonly taken are starlings, house sparrows, blackbirds and song thrushes. Game and poultry chicks are taken in small numbers but not habitually.

The Advisory Committee makes one qualification; the investigation took place in 1936–37, when the Little Owl population was below its highest level. They say that when, some years ago, the species was rapidly increasing, there may have been a local tendency to depart from normal diet owing to greater competition for food or lack of usual kinds. This is exemplified by Mr Lockley's experience at Stockholm Island, when the Little Owl fed largely on storm petrels, birds which owing to their crepuscular and nocturnal feeding habits formed an ideal food supply.

The question of the Little Owl taking game and poultry chicks was considered meticulously; full records are given. Several observers give accounts of Little Owls killing partridge and pheasant chicks, but the result of the investigation is summed up thus: "One game chick in two pellets, another doubtful one in a Little Owl's gizzard...and 7 poultry chicks. Such is the result of 1½ years' intensive search for game and poultry chicks, in the field and in the laboratory."

Tables are given of the remains of insects found in pellets; five were present in enormous numbers: daddy-longlegs or crane fly, common earwig, a carabid beetle (*Pterostichus madidus*), a dung beetle (*Geotrupes stercorarius*) and cockchafer.

The inquiry, though thorough in the localities where the investigations were made, is open to criticism in that it has by no means covered the whole of England. In some counties investigations have been made in several districts, in others only in one or two, while other counties are omitted altogether; in particular the reports from the south-western counties are meagre.

It is significant that the *Report* confirms the three-year investigation of the Little Owl's food from 1918 made by Dr Walter E. Collinge. Opinions of Scientific Institutions in Switzerland, Holland, Germany, Hungary and Denmark are also quoted: they all testify to the preponderating utility of the species.

It appears that the Little Owl is a bird which needs careful watching. So long as its numbers are kept within reasonable limits it seems innocuous in areas where its normal food supply is abundant. In Somerset it has been taken off the protected list for 3 years. At the end of that period its status and character will be reconsidered. This seems a reasonable course.

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